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ENGINE

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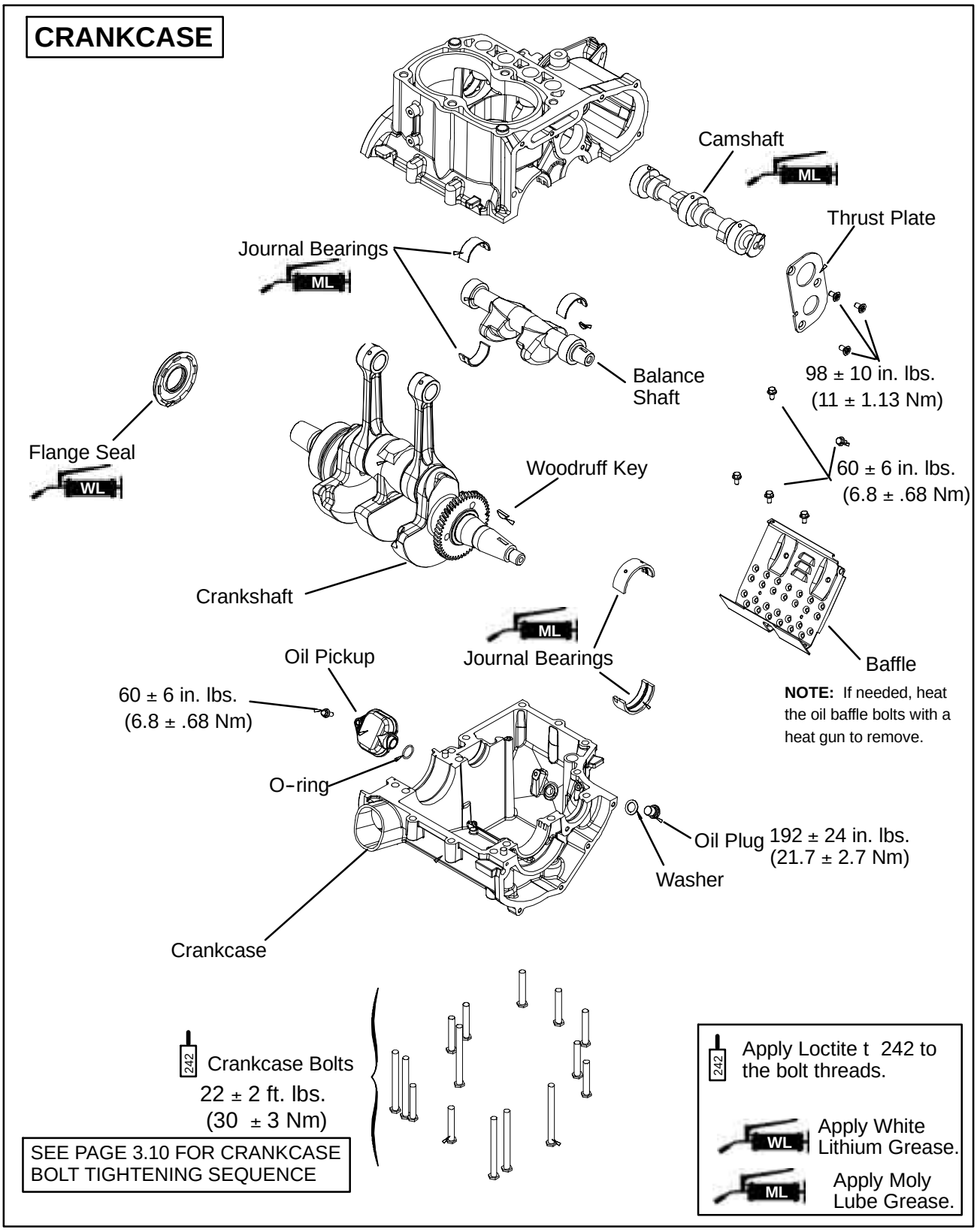
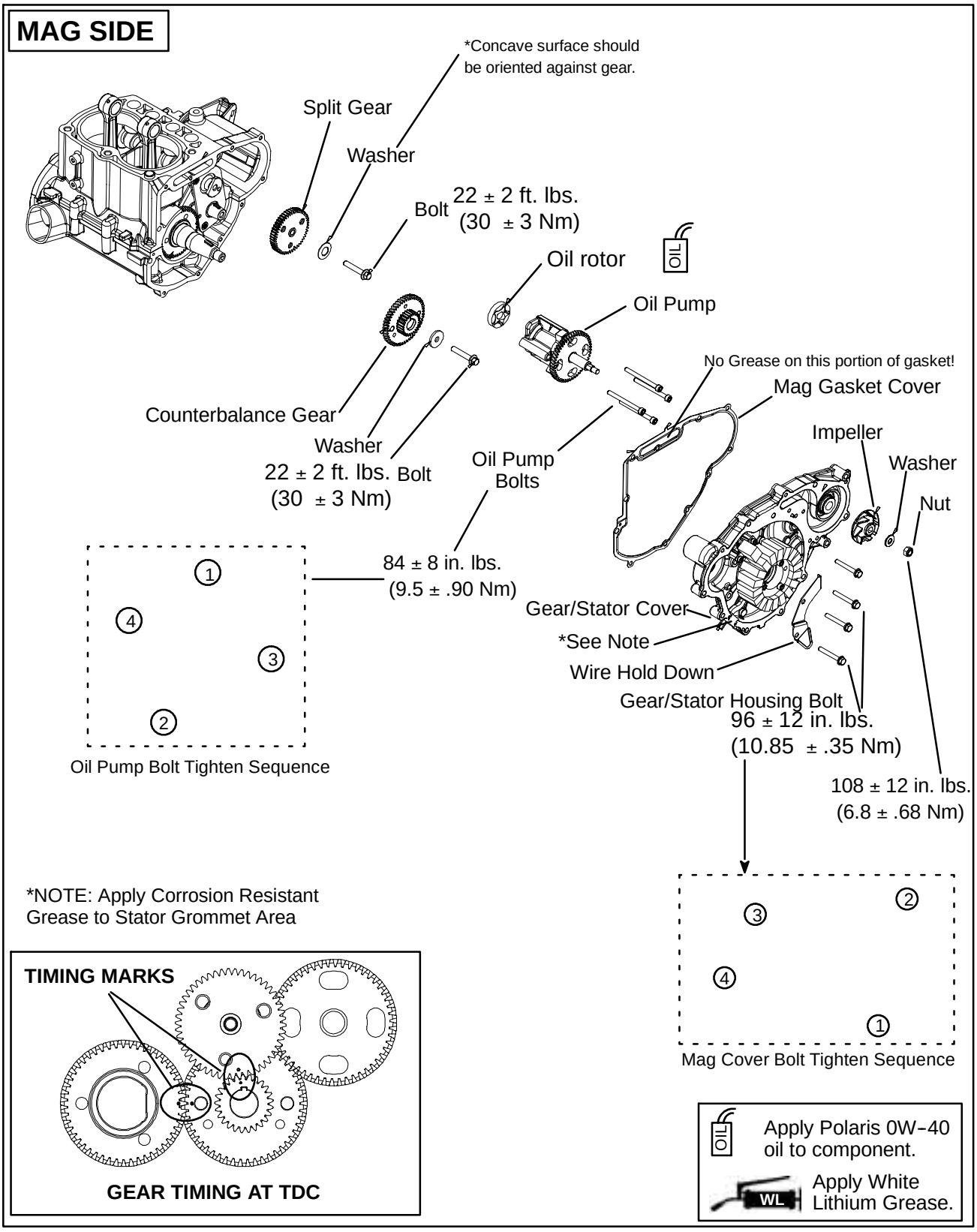
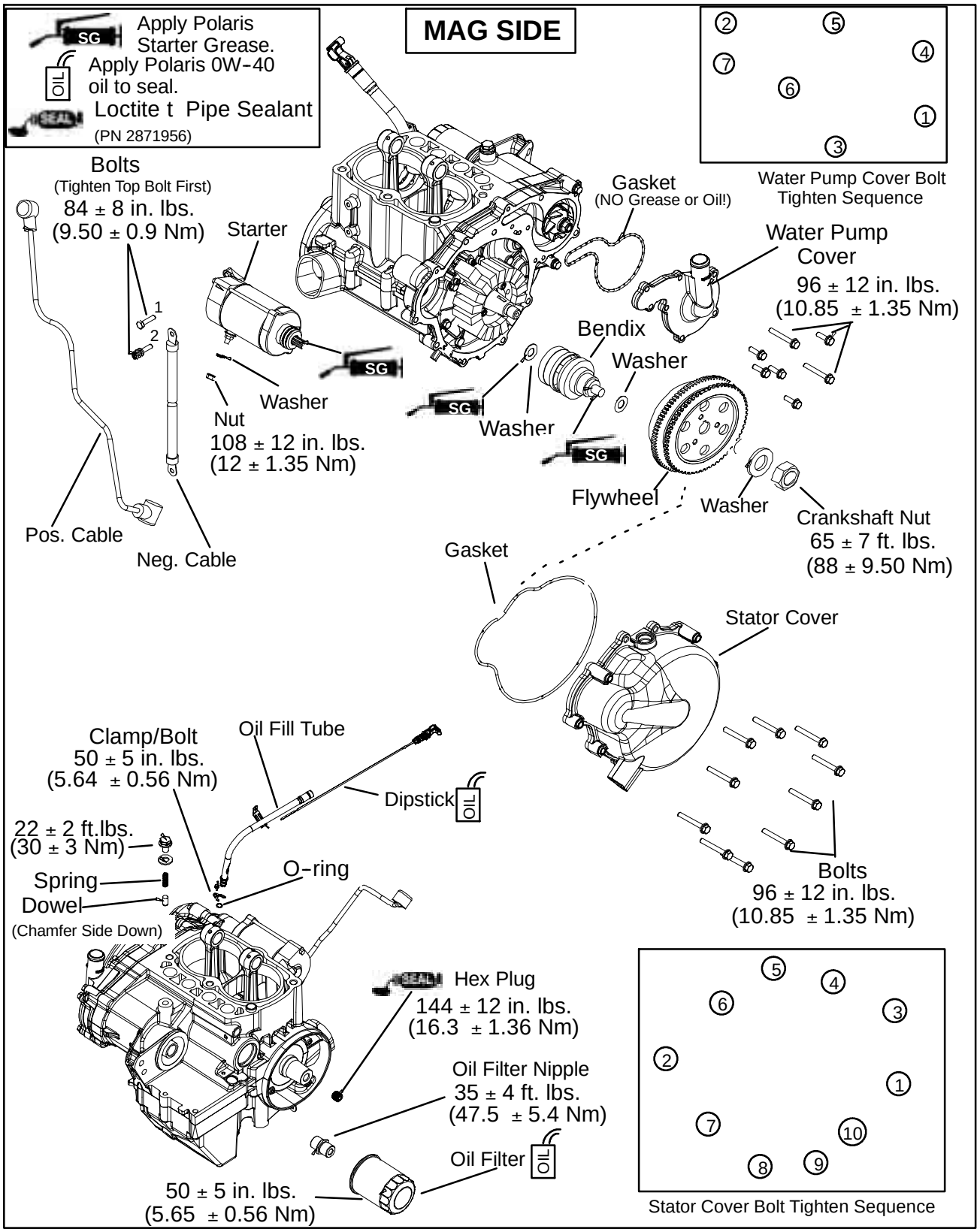
ENGINE EXPLODED VIEW



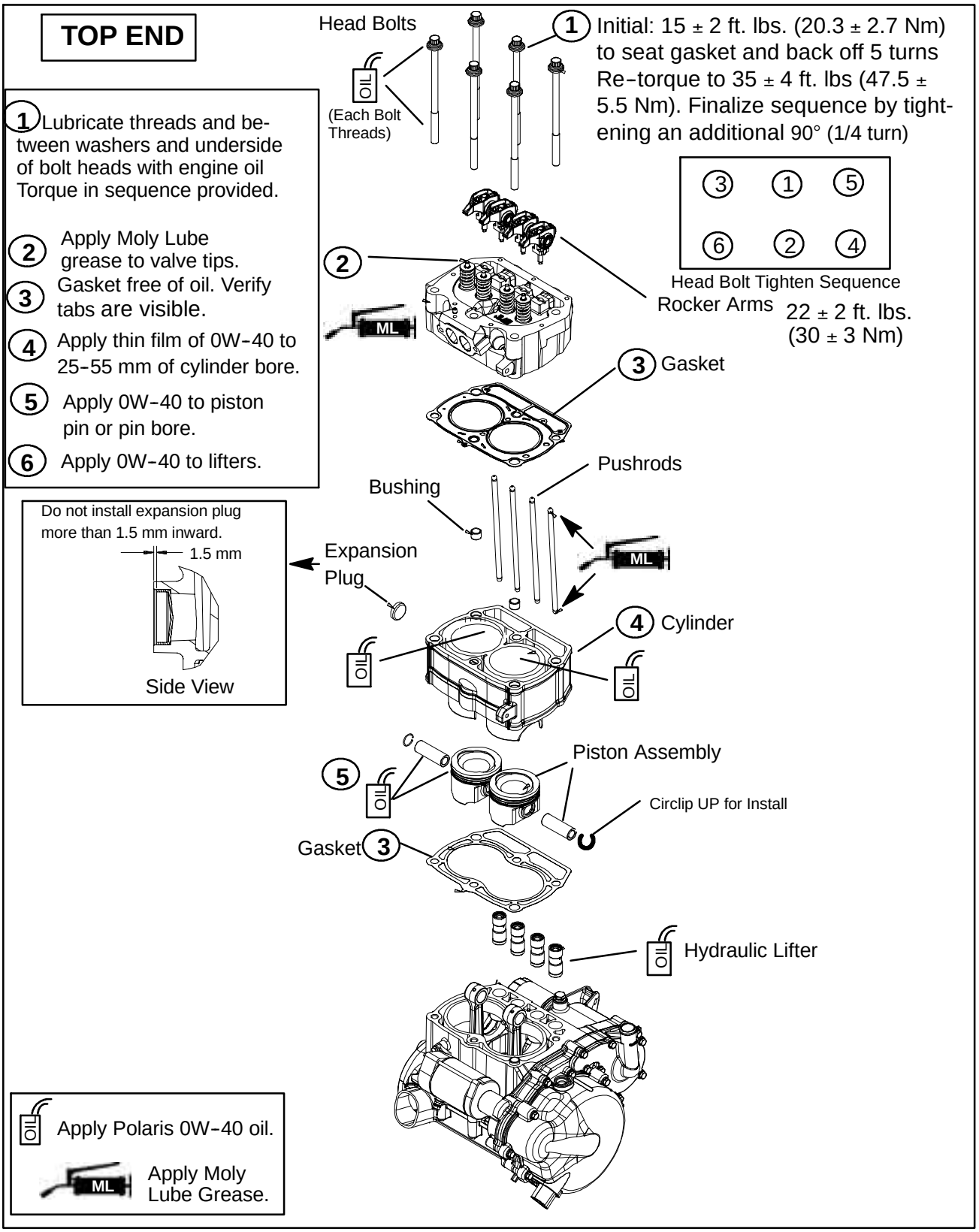
ENGINE EXPLODED VIEW



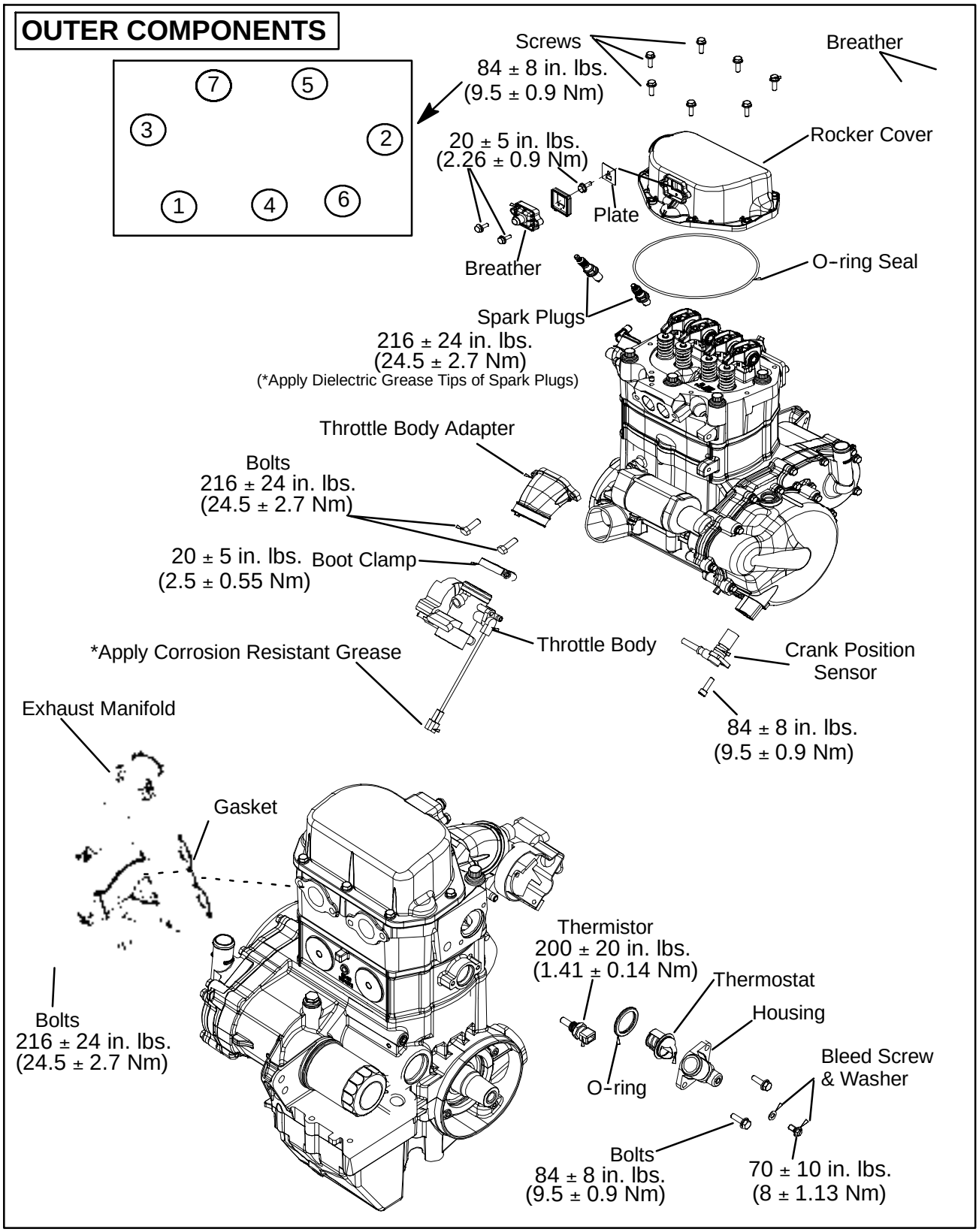
ENGINE EXPLODED VIEW



ENGINE EXPLODED VIEW

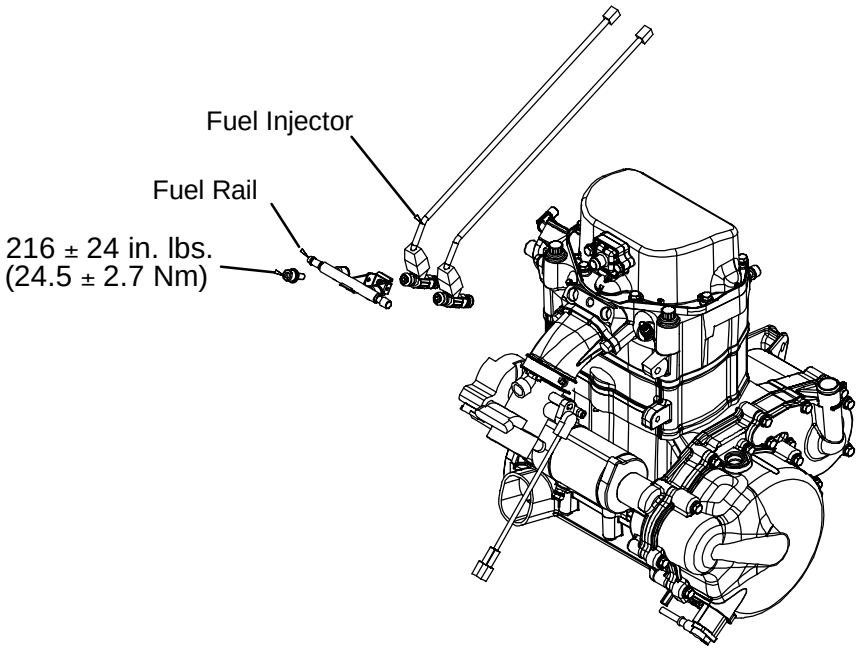

TOP END
Head Bolts
OIL
(Each Bolt Threads)
1 Initial: 15 ± 2 ft. lbs. (20.3 ± 2.7 Nm) to seat gasket and back off 5 turns Re-torque to 35 ± 4 ft. lbs (47.5 ± 5.5 Nm). Finalize sequence by tightening an additional 90° (1/4 turn)
3 1 5
6 2 4
Head Bolt Tighten Sequence
1 Lubricate threads and between washers and underside of bolt heads with engine oil Torque in sequence provided.
2 Apply Moly Lube grease to valve tips.
3 Gasket free of oil. Verify tabs are visible.
4 Apply thin film of 0W-40 to 25-55 mm of cylinder bore.
5 Apply 0W-40 to piston pin or pin bore.
6 Apply 0W-40 to lifters.
2
ML
Rocker Arms
22 ± 2 ft. lbs. (30 ± 3 Nm)
3 Gasket
Pushrods
Bushing
ML
Do not install expansion plug more than 1.5 mm inward.
1.5 mm
Side View
Expansion Plug
4 Cylinder
OIL
OIL
5
OIL
Piston Assembly
Circlip UP for Install
Gasket 3
Hydraulic Lifter
OIL
Apply Polaris 0W-40 oil.
ML
Apply Moly Lube Grease.

ENGINE EXPLODED VIEW



ENGINE EXPLODED VIEW

ELECTRICAL COMPONENTS



NOTE: See Chapter 4 for more information the EFI system.

SPECIAL TOOLS

PART NUMBER	TOOL DESCRIPTION
PV-43527	Oil Filter Wrench
2200634	Valve Seat Reconditioning Kit
PU-45257	Valve Spring Compressor
PU-45652	Valve Pressure Hose
2871043	Flywheel Puller
2870390	Piston Support Block
PU-45497-2	Cam Gear Tooth Alignment Tool
PU-45497-1	Cam Gear Spring Installation Kit (Tapered Pins)
PU-45498	Cam Spanner Wrench
PU-45838	Gear Holder
PA-44995	Water Pump Mechanical Seal Installer
PU-45543	Universal Driver Handle
PA-45483	Main Seal Installer
PA-45658	Main Crankshaft Seal Saver
PA-45401	Water Pump Seal Saver
2870975	Mity Vac t Pressure Test Tool
PU-45778	Oil System Priming Tool

ACCESSIBLE COMPONENTS

The following components can be serviced or removed with the engine installed in the frame:

- Flywheel
- Alternator/Stator
- Starter Motor/Starter Drive
- Cylinder Head
- Cylinder
- Piston/RIngs
- Camshaft
- Rocker Arms
- Oil pump/Water Pump and Oil Pump Drive Gear
- Gear Train Components

The following components require engine removal for service:

- Counterbalance Shaft or Bearing(s)
- Connecting Rod
- Crankshaft
- Crankshaft Main Bearings
- Crankcase

PISTON IDENTIFICATION

Four stroke engine rings have a rectangular profile. See text on Page 3.33 for ring installation. Use the information below to identify pistons and rings.

NOTE: The pistons have no directional identification marks. New pistons are non-directional.

Engine Model No.	Piston Diameter	Standard Piston Identification
EH680OLE23	80 mm	None

TORQUE SPECIFICATIONS

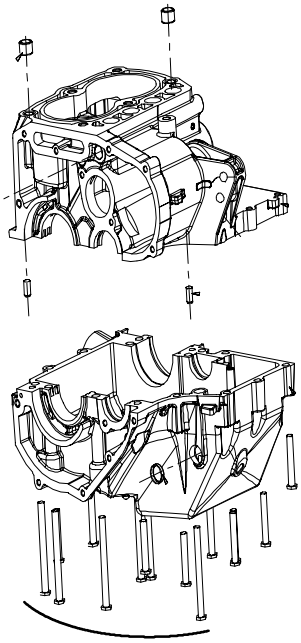
TORQUE SPECIFICATIONS			
Fastener	**Size**	**700 in. Lbs. (Nm)**	**700 ft.lbs. (Nm)**
Camshaft Gear	8 mm	–	22 ± 2 (30 ± 3)
Camshaft Thrust Plate	6 mm	98 ± 10 (11 ± 1.13)	–
Throttle Body Adapter Bolts	8 mm	216 ± 24 (24.5-± 2.7)	–
Counterbalance Gear	8 mm	–	22 ± 2 (30 ± 3)
Crankcase Bolts	8 mm	–	*22 ± 2 (30 ± 3)
Crankcase Breather	5 mm	20 ± 5 (2.5 ± 0.55)	–
Cylinder Head Bolts	11 mm	–	*35 ± 4 (47.5 ± 5.5)
Exhaust Manifold	8 mm	216 ± 24 (24.5 ± 2.70)	–
Flywheel	14 mm	–	65 ± 7 (88 ± 9.50)
Magneto Cover	6 mm	*96 ± 12 (10.85 ± 0.35)	–
Oil Baffle Weldment	5 mm	60 ± 6 (6.8 ± 0.68)	–
Oil Drain Bolt (Crankcase)	12 mm	192 ± 24 (21.7 ± 2.7)	–
Oil Fill Tube Bolt	5 mm	50 ± 5 (5.64 ± 0.56)	–
Oil Filter Pipe Fitting	20 mm	–	35 ± 4 (47.5 ± 5.4)
Oil Pick Up	5 mm	60 ± 6 (6.8 ± 0.68)	–
Oil Pressure Relief Plug	10 mm	22 ± 2 (30 ± 3)	–
Oil Pump Housing Screw	6 mm	*84 ± 8 (9.50 ± 0.90)	–
Rocker Arm	8 mm	–	*22 ± 2 (30 ± 3)
Rocker Cover	6 mm	*84 ± 8 (9.5 ± 0.9)	–
Spark Plug	14 mm	216 ± 24 (24.5 ± 2.7)	–
Starter Motor	6 mm	*84 ± 8 (9.5 ± 0.9)	–
Stator Assembly	6 mm	96 ± 12 (10.85 ± 1.35)	–
Stator Housing	6 mm	*96 ± 12 (10.85 ± 1.35)	–
Temperature Switch	3/8 PT	–	25 ± 3 (34 ± 4)
Thermostat Housing	6 mm	84 ± 8 (9.5 ± 0.9)	–
Thermostat Housing Bleed Screw	6 mm	84 ± 8 (9.5 ± 0.9)	–
Timing Plug	3/4-16	70 ± 10 (8 ± 1.13)	7-9 (10-12 Nm)
Trigger Coil/Stator Wire Holddown	5 mm	*96 ± 12 (10.85 ± 1.35)	–
Water Pump Housing Cover	6 mm	*96 ± 12 (10.85 ± 1.35)	–
Water Pump Impeller Nut	8 mm	108 ± 12 (12 ± 1.35)	–

*** See exploded views for notes or torque sequences.**

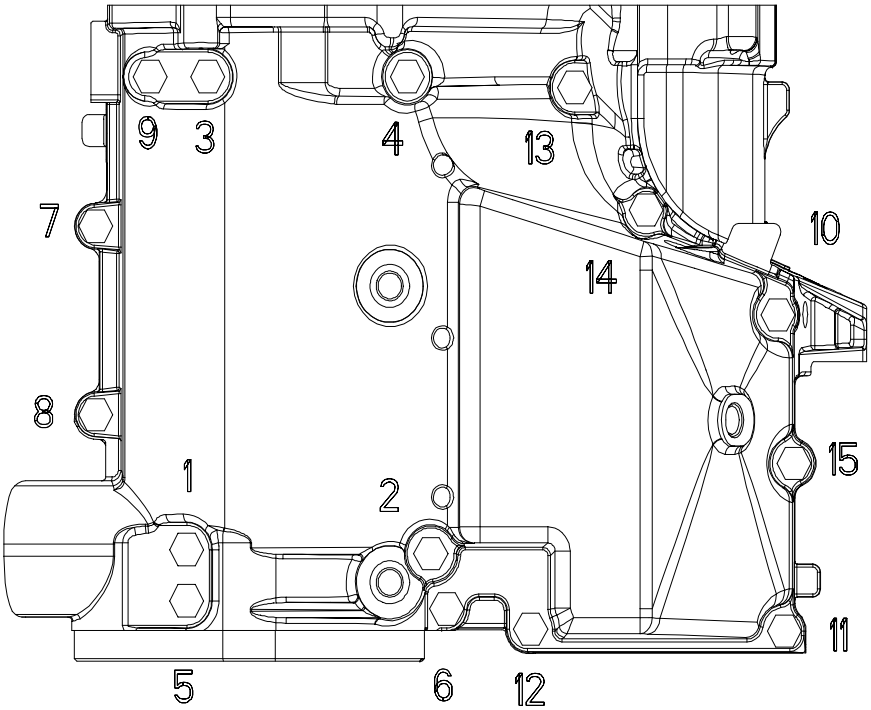
ENGINE FASTENER TORQUE PATTERNS

Tighten cylinder head/cylinder base, and crankcase fasteners in the following sequence outlined below.

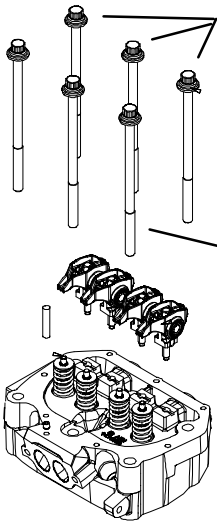
CRANKCASE BOLT TIGHTEN SEQUENCE



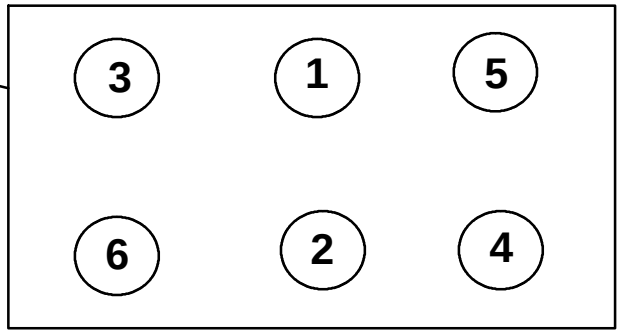
22 ± 2 ft. lbs.
(30 ± 3 Nm)



CYLINDER HEAD BOLT TORQUE SEQUENCE



Lubricate threads, between washer and underside of bolt head with engine oil. Torque in sequence to 15 ± 2 ft. lbs. (20.8 ± 2.7 Nm), allow the gasket to set for 1 minute, then back off 5 turns incrementally in sequence. Re-torque in sequence to 35 ± 4 ft. lbs. (47.5 ± 5.5 Nm). Finalize torque sequence by tightening each bolt an additional 90° (1/4 turn).



700 EFI ENGINE SERVICE DATA

Cylinder Head / Valve				Engine No. - EH068OLE23
Camshaft	Cam lobe height	In	Std	1.308" ± 0.0067" (33.223 ± 0.1702 mm)
		Ex	Std	1.308" ± 0.0067" (33.223 ± 0.1702 mm)
	Camshaft journal OD		Mag	1.654" ± 0.00039" (42 ± 0.010 mm)
			Center	1.634" ± 0.00039" (41.50 ± 0.010 mm)
			PTO	1.614" ± 0.00039" (41 ± 0.010 mm)
	Camshaft journal bore ID		Mag	1.656" ± 0.00039" (42.07 ± 0.010 mm)
			Center	1.637" ± 0.00039" (41.58 ± 0.010 mm)
			PTO	1.617" ± 0.00039" (41.07 ± 0.010 mm)
	Camshaft Oil clearance		Std	0.00118" ± 0.00079" (0.03 ± 0.02 mm)
	End Play			0.0167" ± 0.0098" (0.425 ± 0.25 mm)
Counter Balance	End Play			0.005" (0.127 mm)
Cylinder Head	Surface warpage limit			0.00394" (0.1 mm)
	Standard height			3.478" (88.35 mm)
Valve Seat	Contacting width	In	Std	0.0472" + 0.00787" – 0.0039" (1.20 + 0.20 – 0.10 mm)
		Ex	Std	0.0591" + 0.00787" – 0.0039" (1.50 + 0.20 – 0.10 mm)
	Seat Angle		Std	44.75 ± 0.25°
Valve Guide	Inner diameter			0.2367" ± 0.0003" (6.0122 ± 0.0075 mm)
	Protrusion above head		Intake	0.5610" ± 0.00394" (14.25 ± 0.10 mm)
			Exhaust	0.8071 ± 0.004" (20.50 ± 0.102 mm)
Valve	Margin thickness	In	Std	0.060" ± 0.005" (1.525 ± 0.125 mm)
		Ex	Std	0.070" ± 0.005" (1.78 ± 0.13 mm)
	Stem diameter		In	0.2356" ± 0.00039" (5.985 ± 0.01 mm)
			Ex	0.2351" ± 0.00039" (5.972 ± 0.01 mm)
	Stem oil clearance	Std	In	0.0011" ± 0.00098" (0.0277 ± 0.025 mm)
			Ex	0.0016" ± 0.00039" (0.0407 ± 0.010 mm)
	Overall length		In	4.51" ± 0.01476" (114.5550 ± 0.375 mm)
			Ex	4.5453" ± .01496" (115.45 ± 0.38 mm)
Valve Spring	Overall length		Free Length	1.8267" (46.40 mm)
			Installed Height	1.47" (37.34 mm)

700 EFI ENGINE SERVICE DATA

Cylinder / Piston / Connecting Rod				Engine No. – EH068OLE
Cylinder	Surface warpage limit (mating with cylinder head)			0.004” (0.10 mm)
	Cylinder bore		Std	3.1495” (80 mm)
	Taper limit			0.00031” (0.008 mm)
	Out of round limit			0.00030” (0.0075 mm)
	Piston clearance			
			Limit	.0016” ± .00063” (.041 ± .016 mm)
	Boring limit			N/A
Lifter	Outer Diameter		Std	0.84245” ± 0.00025” (21.39 8± 0.00635 mm)
	Block Bore		Std	0.8438” ± 0.00062”(21.4322 ± 0.0157 mm)
Piston		Std		3.1477” ± .00012l (79.954 ± .003 mm)
	Standard inner diameter of piston pin bore			0.78789” ± .0000098l (20.0125 ± 0.0025 mm)
Piston Pin	Outer diameter			0.7874” – .7872” (20 – 19.995 mm)
	Standard clearance-piston pin to pin bore			0.00059” ± 0.0002” (0.015 ± 0.005 mm)
	Degree of fit			Piston pin must be a push (by hand) fit at 68° F (20° C)
Piston Ring	Piston ring installed gap	Top ring		
			Limit	0.01083” ± 0.00295” (0.275 ± 0.075 mm)
		Second ring		
			Limit	0.0177” ± 0.00394” (0.45 ± 0.10 mm)
		Oil ring		
			Limit	0.0177” ± .00984” (0.45 ± 0.25 mm)
	Standard clearance - piston ring to ring groove	Top ring		
			Limit	0.0019” ± 0.00069” (0.0475 ± 0.0175 mm)
		Second ring		
			Limit	0.0017” ± 0.00049l (0.0425 ± 0.0125 mm)
Connecting Rod	Connecting rod small end ID			.789” – .78841”. (20.030 – 20.015 mm)
	Connecting rod small end radial clearance		Std	0.00098” ± 0.00039” (0.025 ± 0.010 mm)
	Connecting rod big end side clearance			
			Limit	0.01181” ± 0.00591” (0.30 ± 0.15 mm)
	Connecting rod big end radial clearance			
			Limit	0.00015” ± 0.00006” (0.0038 ± 0.0015 mm)
Crankshaft	Crankshaft runout limit			0.00236” (0.060 mm)

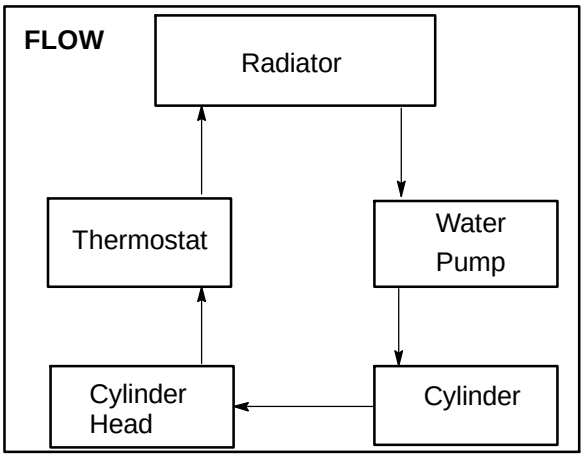
KEY - Std: Standard; OS: Oversize; ID: Inner Diameter; OD: Outer Diameter; Mag: Magneto Side; PTO: Power Take Off Side

COOLING SYSTEM SPECIFICATIONS

System Capacity	3.25 Quarts
Radiator Cap Relief Pressure	13 PSI
Thermostat	Starts opening 179° F (82° C) Fully Open @ 203° F (92° C)

Recommended Coolant

Use only high quality antifreeze/coolant mixed with *distilled* water in a 50/50 or 60/40 ratio, depending on freeze protection required in your area. **CAUTION:** Using tap water in the cooling system will lead to a buildup of deposits which may restrict coolant flow and reduce heat dissipation, resulting in possible engine damage. Polaris Premium 60/40 Antifreeze/Coolant is recommended for use in all cooling systems and comes pre-mixed, ready to use.



COOLING SYSTEM

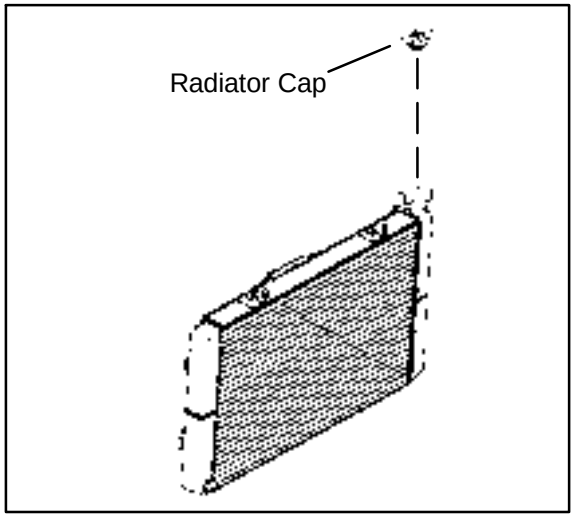
⚠ WARNING

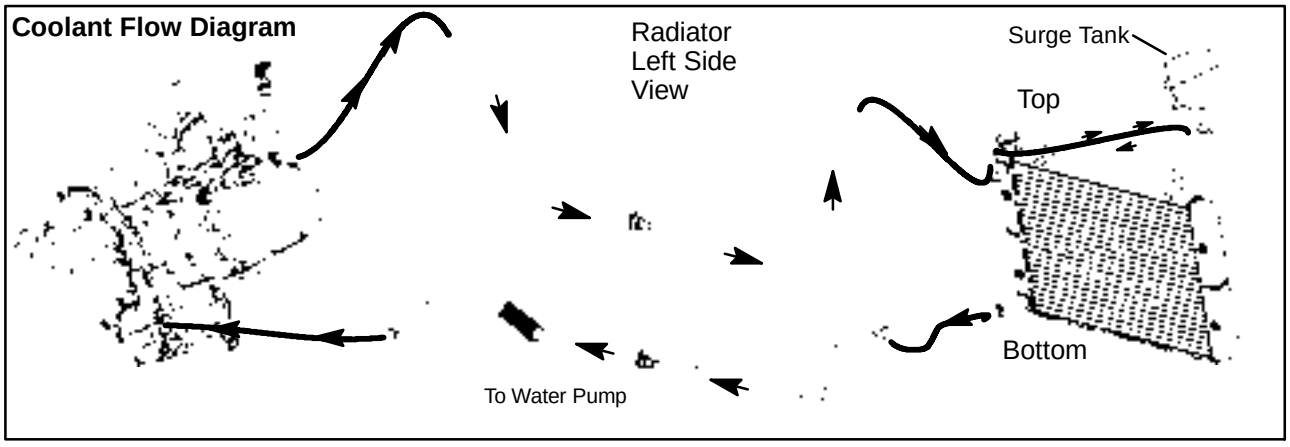
Never remove radiator cap when engine is warm or hot. The cooling system is under pressure and serious burns may result. Allow the engine and cooling system to cool before servicing.

1. Open front hood.
2. Removesurge tank hose from coolant filler neck.
3. Connect a Mity Vac t (**PN 2870975**) to the filler neck nipple and pressurize system to 10 psi. The system must retain 10 psi for five minutes or longer. If pressure loss is evident within five minutes, check the radiator, hoses, clamps and water pump seals for leakage.

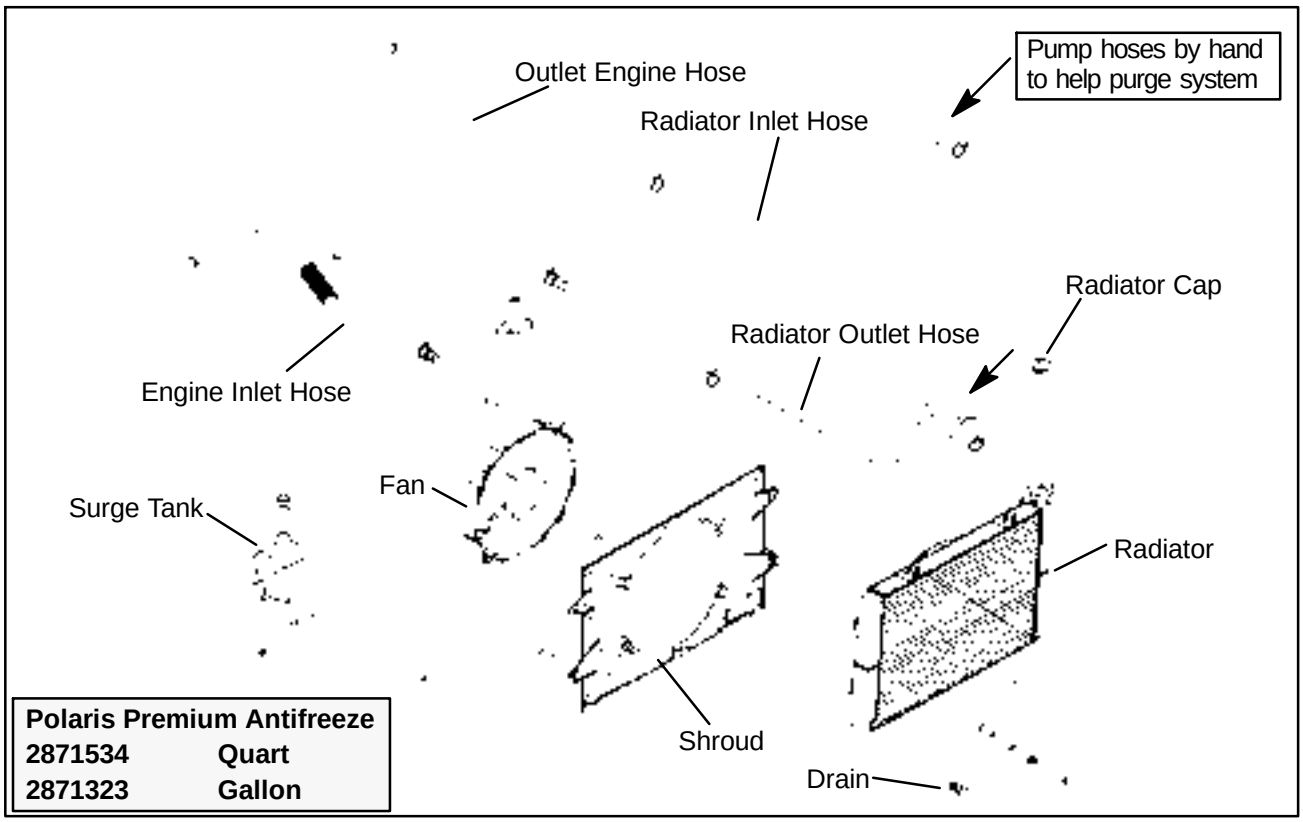
Radiator Cap Pressure Test

1. Remove radiator cap and test cap using a commercially available cap tester.
2. The radiator cap relief pressure is 13 lbs. Replace cap if it does not meet this specification.





COOLING SYSTEM EXPLODED VIEW



COOLING SYSTEM BLEEDING PROCEDURE

⚠ WARNING

Always wear safety glasses and proper shop clothing when performing the procedures in this manual. Failing to do so may lead to possible injury or death.

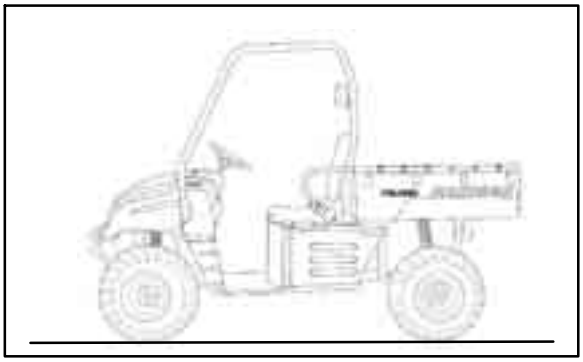
CAUTION: Use caution when performing these procedures. Coolant maybe hot and may cause severe injury or burns.

NOTE: Use this procedure when a unit overheats and no apparent leaks in the cooling system are found.

NOTE: If the coolant level is LOW in the radiator, or if there are leaks in the system, the coolant system will not draw coolant from the reservoir tank.

PROCEDURE 1:

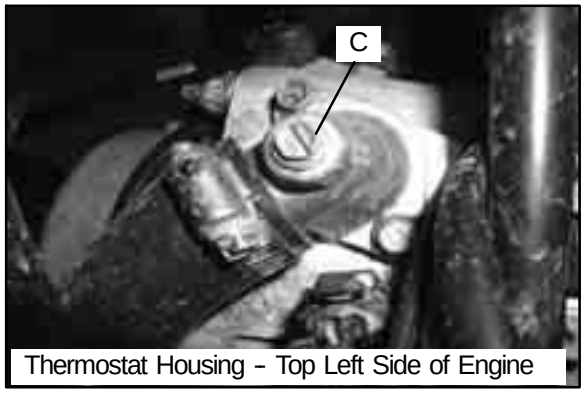
1. Park Machine on a flat surface. Place the vehicle in Neutral and set the parking brake.



CAUTION: Be sure the engine has cooled and there is no pressure built up in the cooling system before removing the radiator cap. The coolant maybe hot and could cause severe injury or burns.

2. Remove radiator cap (A) and top off coolant. Remove surge tank (B) fill cap and fill the surge tank to the full line.

3. Leave the cap off of the radiator to allow any possible air to escape. Start the engine and let it idle for 5-10 minutes or until the thermostat opens and allows coolant to flow through the system.
4. Slightly loosen the bleed screw (C) on the thermostat cover to let air escape. If no air is present, a steady stream of coolant will stream out. If there is air present, the screw will bubble and sputter as the air escapes.



Thermostat Housing – Top Left Side of Engine

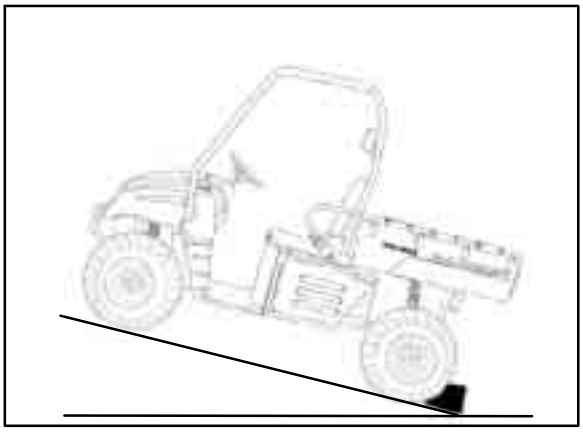
5. Squeeze the coolant lines by hand to help purge the system of air.
6. Add Polaris Premium Antifreeze to the radiator if the level goes down.
7. Tighten the bleed screw to **70 ± 10 in.lbs. (8 ± 1.13 Nm)** on the thermostat housing and properly install the radiator cap.

WARNING: Be sure to install the radiator cap before shutting off the engine. Coolant may spit out of the radiator.

8. Stop the engine and let cool, top off the radiator filler neck with coolant. If you hear or see a "glug" at the filler neck or there is a dropping of the coolant level, indicating that coolant has been pulled into the system. Fill the surge tank only after you have completely filled the cooling system at the radiator filler neck.
9. Repeat this procedure, if overheating still occurs. **If overheating occurs after repeating this procedure, proceed to Procedure 2.**

PROCEDURE 2:

1. Drive the machine onto a slight incline or use properly weight rated ramps. Place the machine in Neutral and set the parking brake. Block the rear wheels. The radiator neck should be above the level of the top of the engine.



CAUTION: Be sure the engine has cooled and there is no pressure built up in the cooling system before removing the radiator cap. The coolant maybe hot and could cause severe injury or burns.

2. Remove radiator cap and top off coolant. Fill the surge tank to the full line.
3. Leave the cap off of the radiator to allow any possible air to escape. Start the engine and let it idle for 5-10 minutes or until the thermostat opens and allows coolant to flow through the system.

NOTE: If there is air in the system you will see air bubbles forming through the radiator fill neck.

4. Add coolant as needed. If no bubbles are seen at the filler neck, the system should be purged of air.
5. Install the radiator cap and turn off the machine.

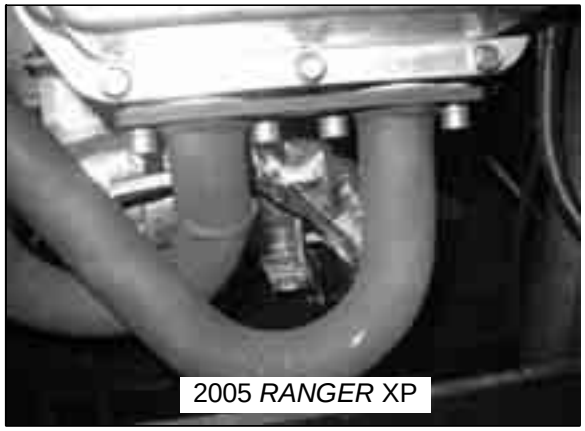
WARNING: Be sure to install the radiator cap before shutting off the engine. Coolant may spit out of the radiator.

ENGINE REMOVE & INSTALL

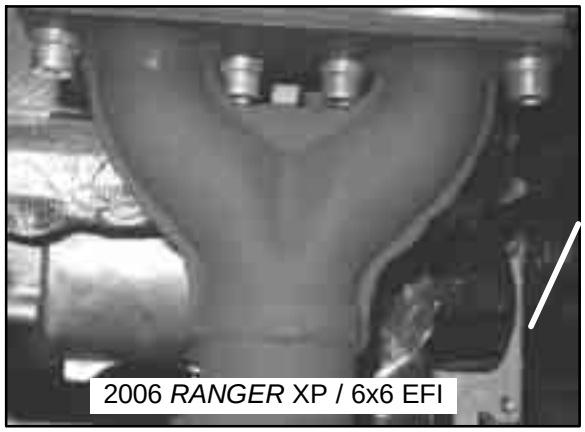
⚠ WARNING

Always wear safety glasses and proper shop clothing when performing the procedures in this manual. Failing to do so may lead to possible injury or death.

1. Clean work area.
2. Thoroughly clean the engine and chassis.
3. Disconnect battery negative (-) cable.
4. Remove the following parts as required:
   - Seat
   - Storage Unit under driver seat (Refer to Chapter 5)
5. Remove middle dog house cover and remove exhaust pipe bolts.

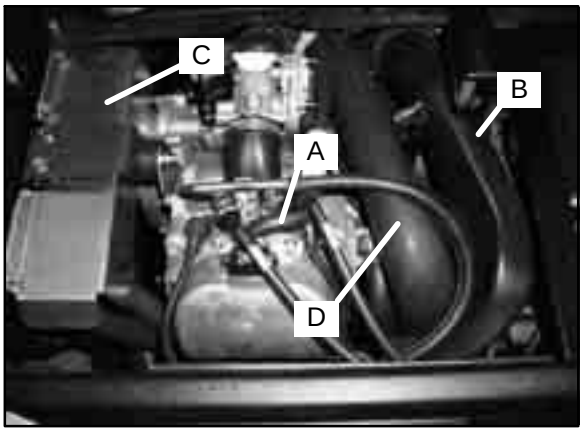


2005 *RANGER* XP

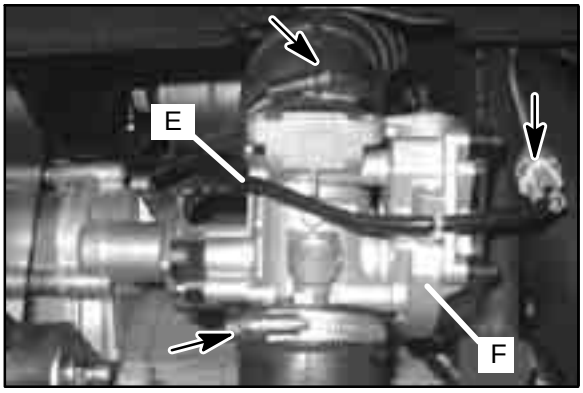


2006 *RANGER* XP / 6x6 EFI

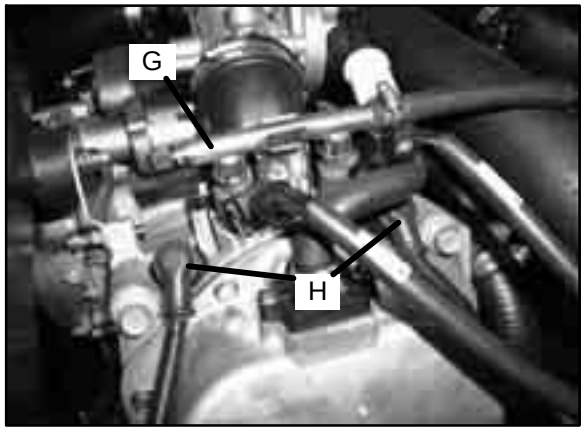
6. Remove springs from exhaust pipe and remove pipe.
7. Refer to PVT System Chapter 6 to remove outer clutch cover, drive belt, drive clutch, driven clutch, and inner cover.
8. Drain coolant and engine oil.
9. Remove the air breather line (A).
10. Remove PVT exhaust duct (B).
11. Remove the exhaust shield (C).
12. Disconnect the air intake hose (D) from the air box and remove the air intake hose.



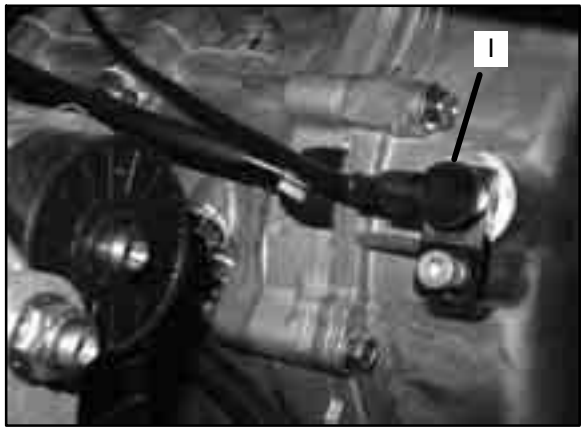
13. Disconnect the throttle body sensor (E) at the electrical connector. Remove the clamps that secure the throttle body (F) to the air intake boot and engine intake boot. Remove the throttle body (F). Insert a shop towel into the engine intake to prevent dirt from entering the intake port.



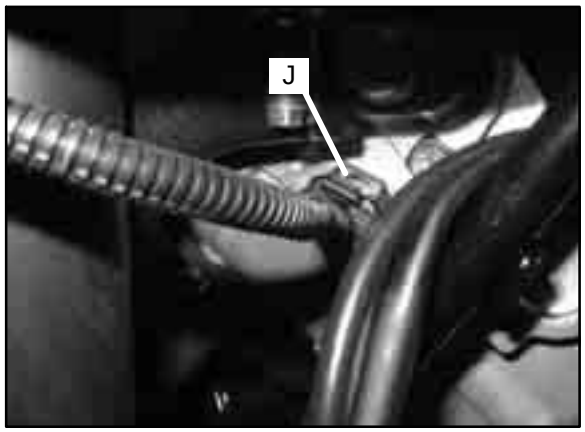
14. Relieve the fuel pressure in the fuel rail (refer to Chapter 4, “FUEL INJECTION”) for proper procedure. Carefully remove the fuel rail (G) and injectors.
15. Remove the spark plug leads (H).



16. Remove the crank position sensor (I) located on the mag cover.



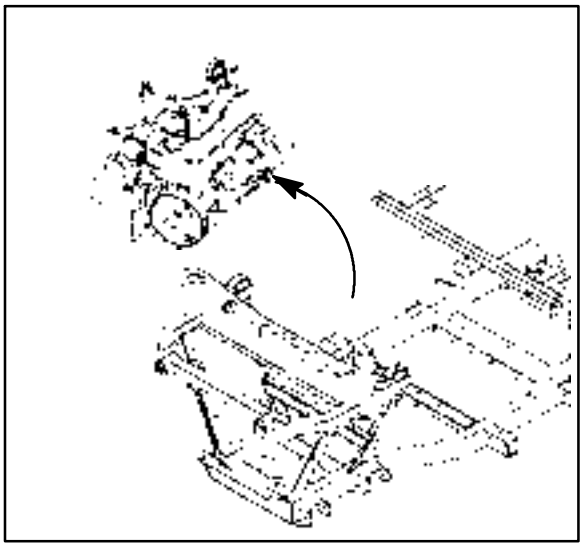
17. Disconnect the coolant temperature sensor (J) from the left side of the cylinder.



18. Disconnect the coolant hoses. Properly dispose of any antifreeze from the engine or hoses.
19. When removing starter cables, note and mark ground cable and positive (+) cable mounting angle and locations . Remove cables.
20. Remove all engine mount nuts and / or engine mount plates.
21. With all hoses and wires disconnected, the engine can be pulled straight out of the chassis.

NOTE: Rotating the engine to the left 90 degrees (valve cover facing left), may ease engine removal.

NOTE: Use caution when lifting the engine out of frame. Use an engine lift or other means if the engine is too heavy to be lifted manually.



22. For engine installation, reverse procedures.

ENGINE INSTALLATION NOTES

After the engine is installed in the frame, review this checklist and perform all steps that apply:

General Items

1. Install previously removed components using new gaskets, seals, and fasteners where applicable.

NOTE: Properly route all electrical harnesses and re-attach any fasteners or protective tubing. Check for any possible rubbing points of electrical wires.

2. Perform regular checks on fluid levels, controls, and all important areas on the vehicle as outlined in the daily pre-ride inspection checklist (refer to Chapter 2 or the Owner's Manual).
1. Adjust center distance of drive and driven clutch. (Chapter 6)
2. Adjust clutch offset, alignment, and belt deflection. (Chapter 6)
3. Clean clutch sheaves thoroughly and inspect inlet and outlet ducts for proper routing and sealing. (Chapter 6)

Transmission

1. Inspect transmission operation and adjust linkage if necessary. Refer to Chapter 2 and Chapter 8.

Exhaust

1. Replace exhaust gaskets. Seal connections with high temp silicone sealant.
2. Check to be sure all springs are in good condition.

Bleed Cooling System

NOTE: Follow coolant bleeding procedure outlined earlier in the chapter.

Engine Break In Period

The break in period for a Polaris twin cylinder engine is defined as the first ten hours of operation, or the time it takes to use two full tanks of gasoline. No single action on your part is as important as a proper break in period. Careful treatment of a new engine will result in more efficient performance and longer life for the engine. Perform the following procedures carefully.

CAUTION

Use only Polaris Premium 0-40W All Season synthetic oil or equivalent. Never substitute or mix oil brands. Serious engine damage and voiding of warranty can result.

Do not operate at full throttle or high speeds for extended periods during the first three hours of use. Excessive heat can build up and cause damage to close fitted engine parts.

1. Fill fuel tank with unleaded or leaded fuel which has a minimum pump octane number of 87= (R+ M)/2.
2. Check oil reservoir level indicated on dipstick. Add oil if necessary.

3. Drive slowly at first to gradually bring engine up to operating temperature.
4. Vary throttle positions. Do not operate at sustained idle or sustained high speed.
5. Perform regular checks on fluid levels, controls and all important areas on the vehicle.
6. Pull only light loads during initial break in.
7. Change break in oil and filter at 20 hours or 200 miles.

CYLINDER HONE SELECTION AND HONING PROCEDURE

CAUTION:

A hone which will straighten as well as remove material from the cylinder is very important. Using a common spring loaded glaze breaker for honing is not advised for nicasil cylinders. Polaris recommends using a rigid hone or arbor honing machine.

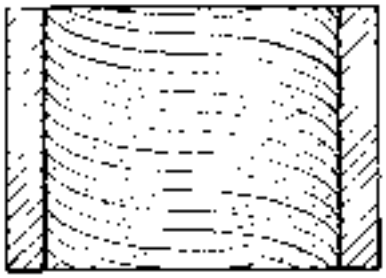
Cylinders may be wet or dry honed depending upon the hone manufacturer's recommendations. Wet honing removes more material faster and leaves a more distinct pattern in the bore.

HONING TO DEGLAZE

A finished cylinder should have a cross-hatch pattern to ensure piston ring seating and to aid in the retention of the fuel/oil mixture during initial break in. Hone cylinder according to hone manufacturer's instructions, or these guidelines:

- Honing should be done with a diamond hone. Cylinder could be damaged if the hone is not hard enough to scratch the nicasil lining.
- Use a motor speed of approximately 300-500 RPM, run the hone in and out of the cylinder rapidly until cutting tension decreases. Remember to keep the hone drive shaft centered (or cylinder centered on arbor) and to bring the stones approximately 1/2″ (1.3 cm) above and below the bore at the end of each stroke.
- Release the hone at regular intervals and inspect the bore to determine if it has been sufficiently deglazed, and to check for correct cross-hatch. **NOTE**: **Do not allow cylinder to heat up during honing**.
- After honing has been completed, inspect cylinder for thinning or peeling.

If cylinder wear or damage is excessive, it will be necessary to replace the cylinder. The cylinders are lined with a nicasil coating and are not repairable. Hone only enough to deglaze the outer layer of the cylinder bore.



EXAMPLE OF CROSS HATCH PATTERN

IMPORTANT: Clean the Cylinder After Honing

It is very important that the cylinder be thoroughly cleaned after honing to remove all grit material. Wash the cylinder in a solvent, then in hot, soapy water. Use electrical contact cleaner if necessary to clean these areas. Rinse thoroughly, dry with compressed air, and oil the bore immediately with Polaris 4 Cycle Lubricant to prevent the formation of surface rust.

ENGINE LUBRICATION

Oil Type – Polaris Premium 0W–40 Synthetic **(PN 2871281)**

Capacity – Approximately 2 U.S. Quarts (1.9 l)

Filter – (**PN 2540086**)

Filter Wrench – PV–43527 or equivalent

Oil Pressure Specification – 35–39 PSI @ 5500 RPM, Polaris 0W–40 Synthetic , Engine at operating temperature.

OIL PRESSURE TEST

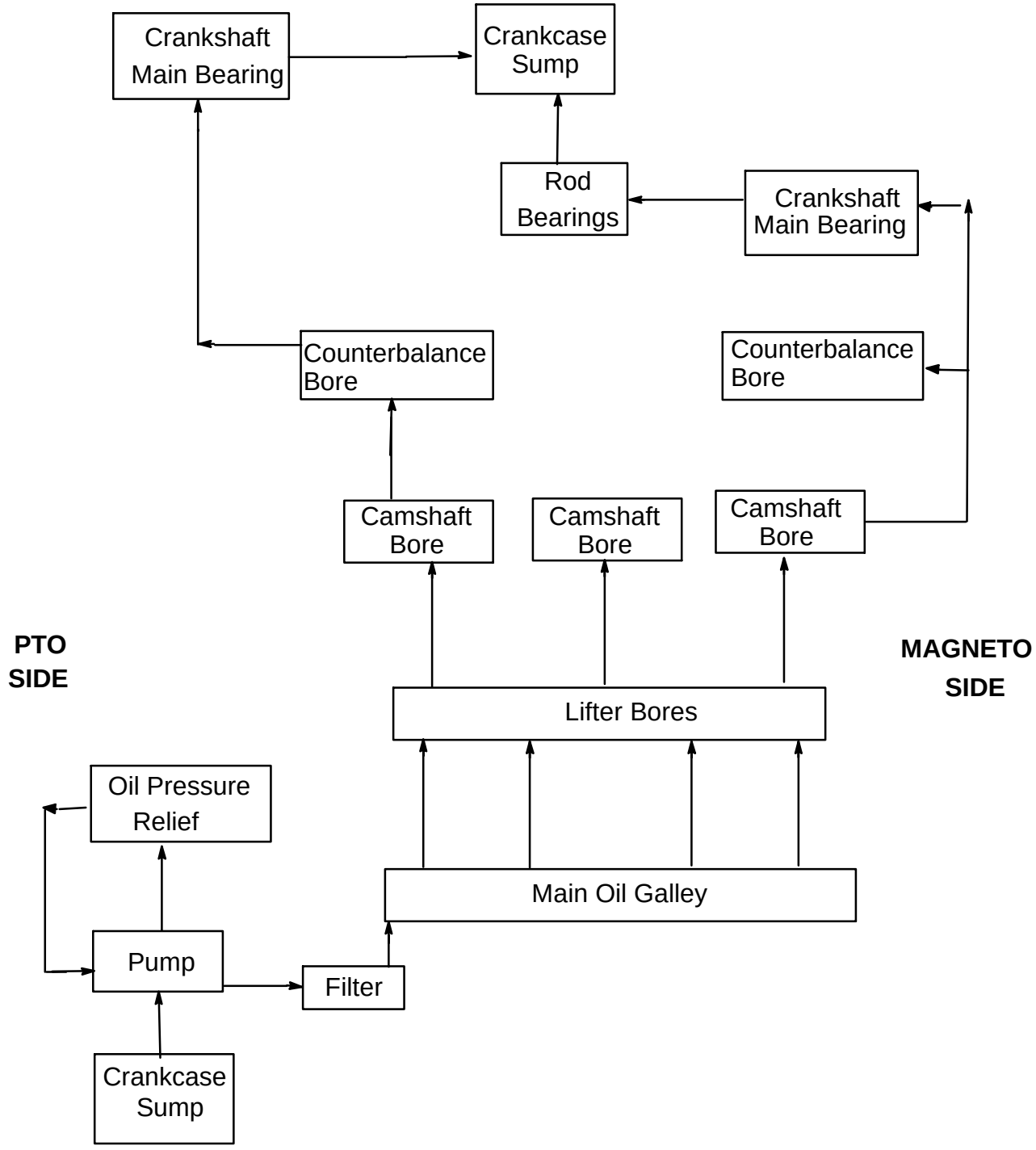
1. Remove blind plug/sender from left side of crankcase.
2. Insert a 1/8 NPT oil pressure gauge adaptor into the crankcase and attach the gauge.
3. Start engine and allow it to reach operating temperature, monitoring gauge indicator.

NOTE: Use only Polaris Premium 0W–40 Synthetic Engine Lubricant.

Oil Pressure at 5500 RPM (Engine Hot):
Standard: 39 PSI
Minimum: 35 PSI

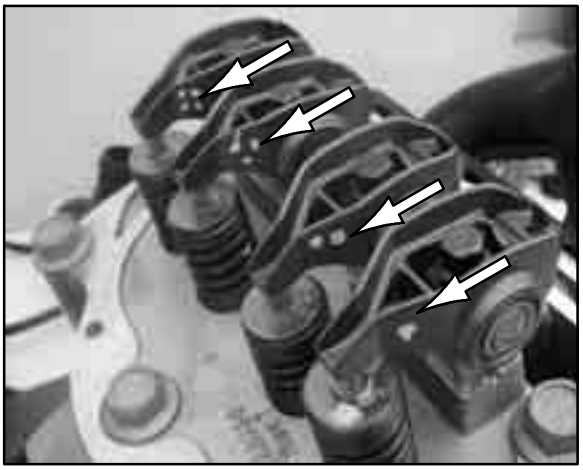
OIL FLOW

This chart describes the flow of oil through the EH68 engine. Beginning in the crankcase sump, the oil is drawn through an oil galley to the feed side of the oil pump. The oil is then pumped through the oil filter. If the oil filter is obstructed, a bypass valve contained in the filter allows oil to bypass the filter element. At this point, the oil is supplied to the main oil galley through a crankcase passage. Oil is then diverted three ways from the main oil galley, with the first path entering the camshaft bores, onto the rear balance shaft journal and then draining back into the crankcase sump. The second oil path from the main oil galley feeds the lifter bores and then drains back to the crankcase sump. The third oil path flows through a crankcase galley to the MAG side crankshaft journal and also to the front balance shaft journal and onto the crankcase sump. The oil pressure switch is fed off the main oil galley.



ROCKER ARM INSPECTION

1. Mark or tag rocker arms in order of disassembly to keep them in order for reassembly.



2. Inspect the wear pad at the valve end of the rocker arm for indications of scuffing or abnormal wear. If the pad is grooved, replace the rocker arm.

NOTE: Do not attempt to true this surface by grinding.

3. Check the rocker arm pad and fulcrum seat for excessive wear, cracks, nicks or burrs.

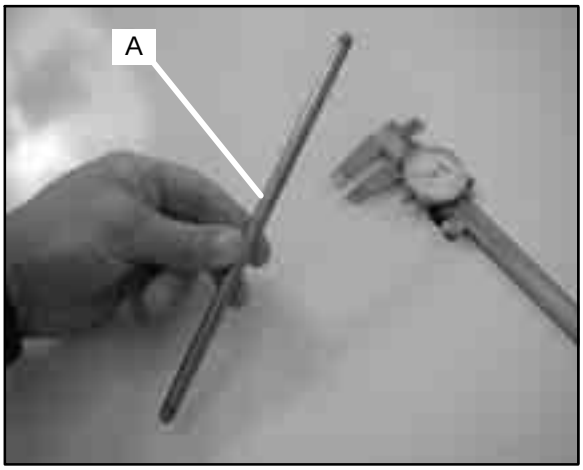
PUSH ROD INSPECTION

1. Clean push rods (A) in a suitable solvent. Blow dry push rods with compressed air.
2. Use compressed air to confirm the oil passage is clear in the center of the push rod.

⚠ WARNING

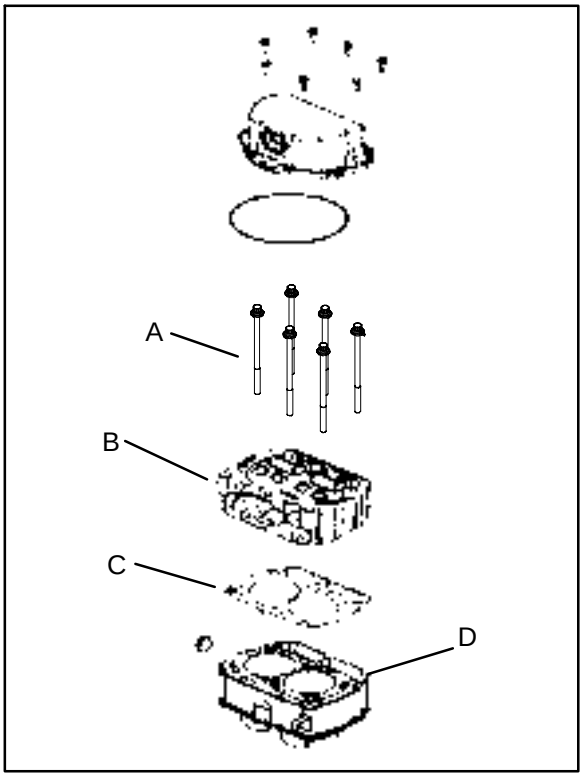
Always wear safety glasses when working with compressed air to prevent personal injury.

3. Check the ends of the push rods (A) for nicks, grooves, roughness or excessive wear.
4. The push rods (A) can be visually checked for straightness while they are installed in the engine by rotating them with the valve closed. Push rods can also be checked with a dial indicator or rolled across a flat surface to check for straightness.
5. If the push rod (A) is visibly bent, it should be replaced.



CYLINDER HEAD REMOVAL

1. Loosen the six cylinder head bolts evenly 1/8 turn each in a criss-cross pattern until loose.
2. Remove bolts (A) and tap cylinder head (B) lightly with a soft face hammer until loose. **CAUTION:** Tap only in reinforced areas or on thick parts of cylinder head casting to avoid damaging the head or cylinder.
3. Remove cylinder head (B) and head gasket (C) from the cylinder (D).



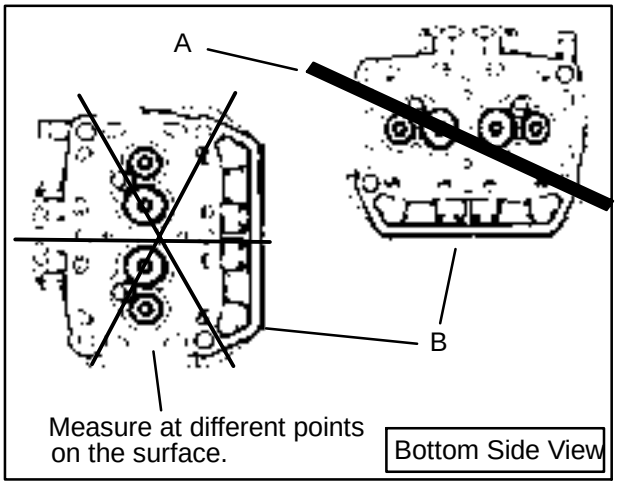
CYLINDER HEAD INSPECTION

1. Thoroughly clean cylinder head surface to remove all traces of gasket material and carbon.

CAUTION: Use care not to damage sealing surface.

CYLINDER HEAD WARPAGE

1. Lay a straight edge (A) across the surface of the cylinder head (B) at several different points and measure warpage by inserting a feeler gauge between the straight edge and the cylinder head surface. If warpage exceeds the service limit, replace the cylinder head.



Cylinder Head Warpage Limit:

004″ (.1016 mm) Max.

CYLINDER HEAD DISASSEMBLY

NOTE: The following procedure is only for servicing the top end of the valve train when replacing valve springs or replacing valve seals.

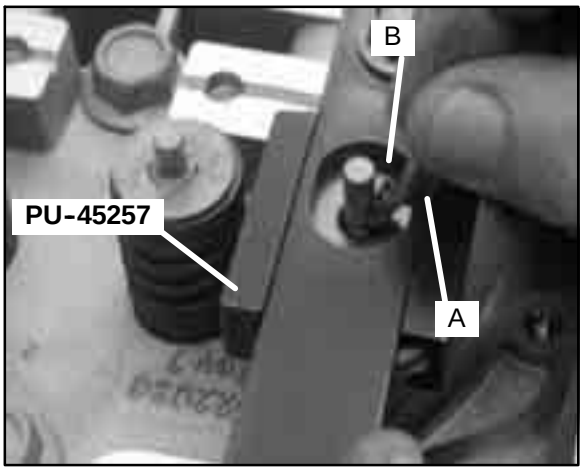
Valve Train Servicing

In some cases the valve train can be serviced while the cylinder head is still on the engine. Keep all parts in order with respect to their location in the cylinder head.

⚠ WARNING

Wear eye protection or a face shield during cylinder head disassembly and reassembly.

1. Having already removed the valve cover, rocker arms and pushrods, align the cylinder to be worked on at top dead center. Install the Valve Pressure Hose (**PU-45652**) into the spark plug hole. Hook the hose to an air compressor and supply 50 to100 psi to the hose. This will seat the valves during valve spring removal. Do not remove air from the hose at anytime until reassembly is completed.
2. Using the Valve Spring Compressor (**PU-45257**), compress the valve spring and remove the valve keepers. **NOTE:** A small parts magnet (A) can aid in the removal of the retainers (B).



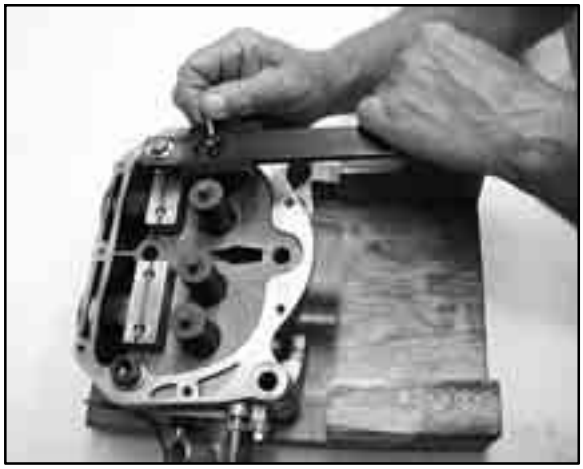
Valve Spring Compressor:
(PU-45257)
Valve Pressure Hose:
(PU-45652)

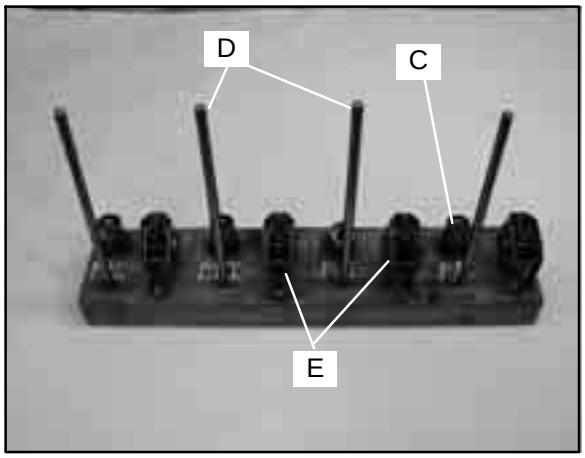
NOTE: To prevent damage to the valve seals, do not compress the valve spring more than is needed to remove the valve keepers.

3. Remove spring retainer and spring.
4. The valve seals are now serviceable.

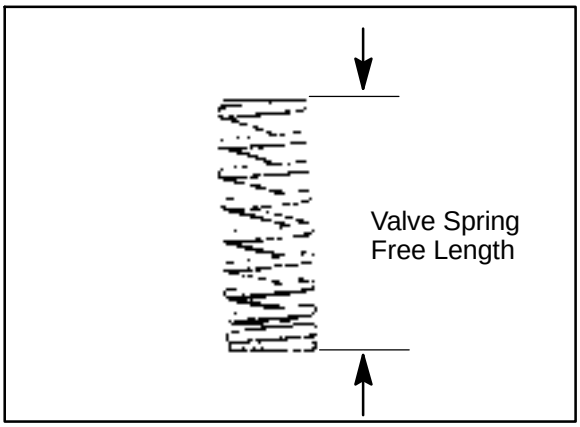
CYLINDER HEAD DISASSEMBLY, CONT.

NOTE: Carefully remove the cylinder components. Place the hydraulic lifters (C), pushrods (D), and rocker arms (E) in a safe, clean area.





5. Measure free length of spring with a Vernier caliper. Compare to specifications. Replace spring if measurement is out of specification.

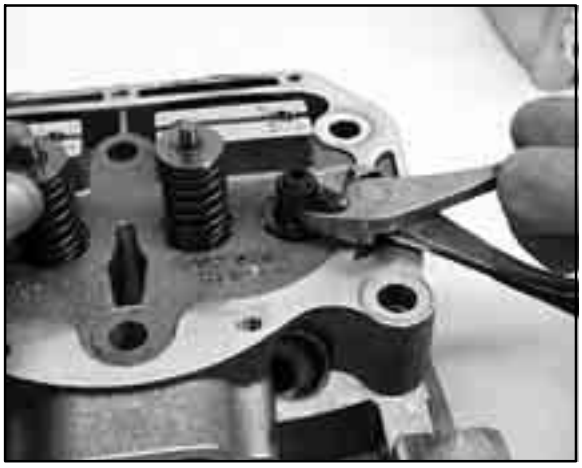


Valve Spring Length:

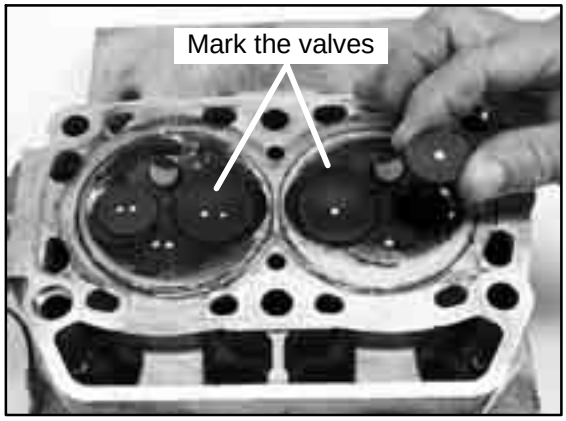
Std: 1.827" (46.40 mm)

Installed Height: 1.47" (37.34 mm)

6. Remove valve guide seals. **IMPORTANT:** It is recommended to replace seals whenever the cylinder head is disassembled. Hardened, cracked or worn valve seals will cause excessive oil consumption and carbon buildup.

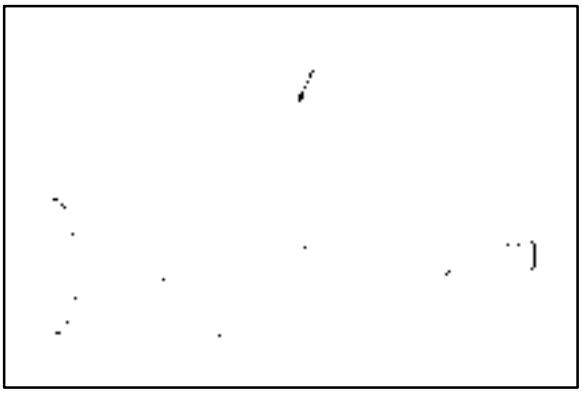


7. Mark the valves with a white pen. Remove the valves from the cylinder head. This will ensure that the valves are properly placed during engine reassembly.

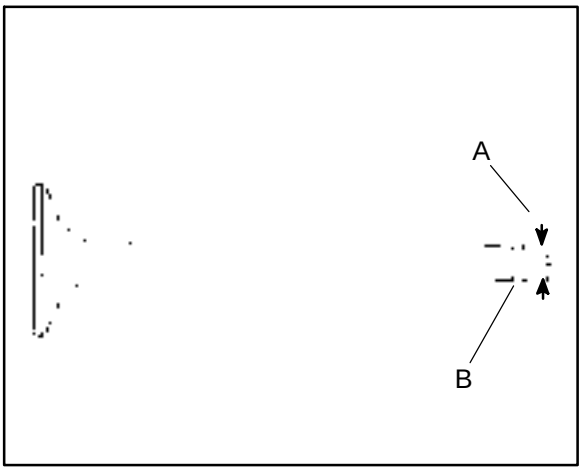


VALVE INSPECTION

1. Remove all carbon from valves with a soft wire wheel or brush.
2. Check valve face for runout, pitting, and burnt spots. To check for bent valve stems, mount valve in a drill or use "V" blocks and a dial indicator.



3. Check end of valve stem for flaring, pitting, wear or damage (A).



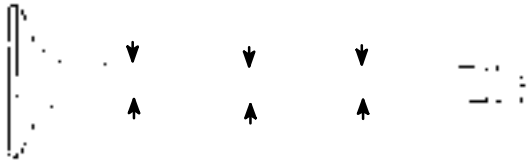
4. Inspect split keeper groove for wear or flaring of the keeper seat area (B). **NOTE:** The valves can be re-faced or end ground, if necessary. They must be replaced if extensively worn, burnt, bent, or damaged.
5. Measure diameter of valve stem with a micrometer in three places, then rotate 90 degrees and measure again (six measurements total). Compare to specifications.

Valve Stem Diameter:

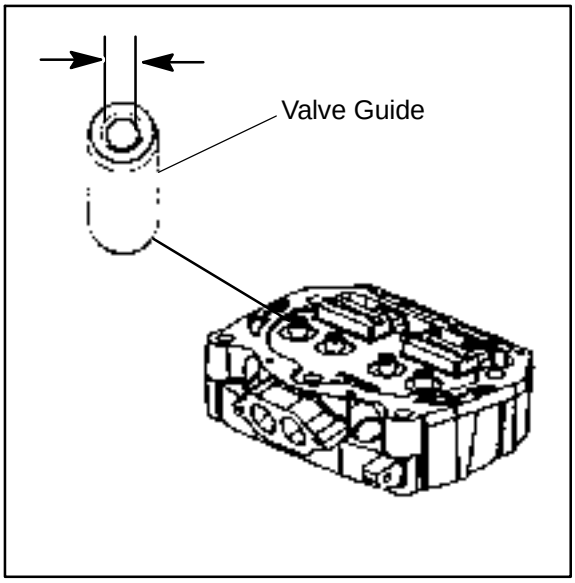
Intake: 0.2356" ± 0.00039" (5.985 ± 0.01 mm)

Exhaust: 0.2351" ± 0.00039" (5.972 ± 0.01 mm)

Measure valve stem in several places. Rotate the valve 90 degrees and measure for wear.



6. Measure valve guide inside diameter at the top middle and end of the guide using a small hole gauge and a micrometer. Measure in two directions.



Valve Guide I.D.:

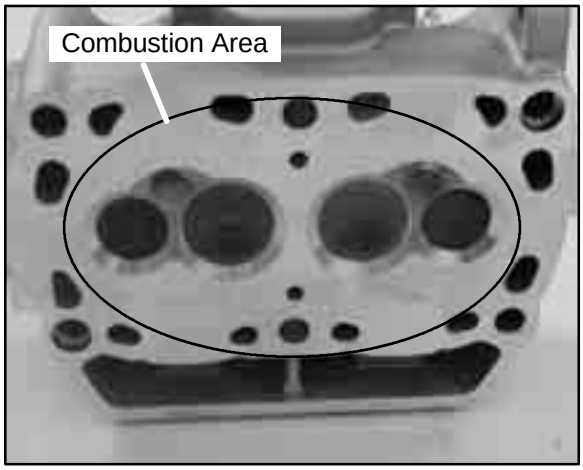
0.2367" ± 0.0003" (6.0122 ± 0.0075 mm)

7. Subtract valve stem measurement from the valve guide measurement to obtain stem to guide clearance. **NOTE: The valve guides cannot be replaced.** Be sure to measure each guide and valve combination individually.

COMBUSTION CHAMBER

1. Clean all accumulated carbon deposits from combustion chamber and valve seat area with carbon cleaner and a soft plastic scraper.

IMPORTANT: Do not use a wire brush, metal scraper, or abrasive cleaners to clean the bottom of the cylinder head. Extensive damage to the cylinder head may result. Wear safety glasses during cleaning.



VALVE SEAT RECONDITIONING

Cylinder Head Reconditioning

NOTE: Polaris recommends that the work be done by a local machine shop that specializes in this area.

NOTE: The cylinder head valve guides cannot be replaced.

⚠ WARNING

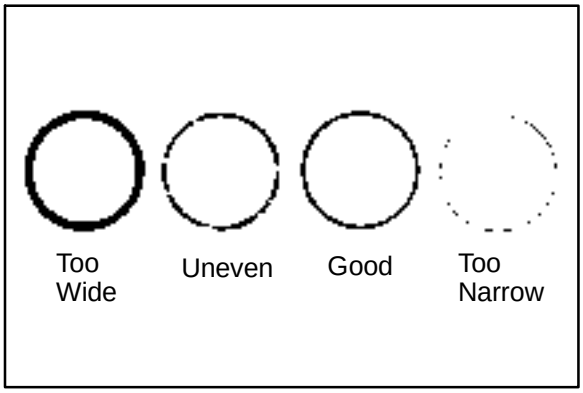
Wear eye protection or a face shield during cylinder head disassembly and reassembly.

Valve Seat Inspection

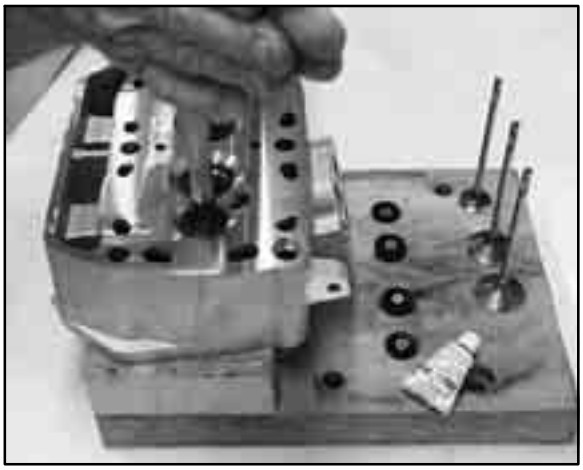
Inspect valve seat in cylinder head for pitting, burnt spots, roughness, and uneven surface. If any of the above conditions exist, the valve seat must be reconditioned. *If the valve seat is cracked the cylinder head must be replaced.*

Follow the manufacturers instructions provided with the valve seat cutters in the Cylinder Head Reconditioning Kit (**PN 2200634**). Abrasive stone seat reconditioning equipment can also be used. Keep all valves in order with their respective seat.

NOTE: Valve seat width and point of contact on the valve face is very important for proper sealing. The valve must contact the valve seat over the entire circumference of the seat, and the seat must be the proper width all the way around. If the seat is uneven, compression leakage will result. If the seat is too wide, seat pressure is reduced, causing carbon accumulation and possible compression loss. If the seat is too narrow, heat transfer from valve to seat is reduced. The valve may overheat and warp, resulting in burnt valves.



1. Install pilot into valve guide.

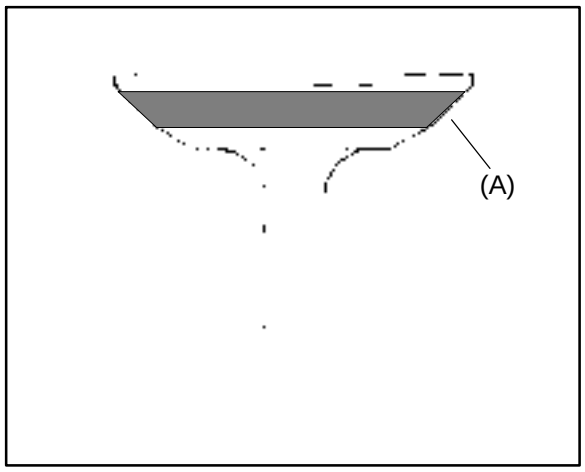


2. Apply cutting oil to valve seat and cutter.
3. Place 46° cutter on the pilot and make a light cut.
4. Inspect the cut area of the seat:
   - If the contact area is less than 75% of the circumference of the seat, rotate the pilot 180° and make another light cut.
   - If the cutter now contacts the uncut portion of the seat, check the pilot. Look for burrs, nicks, or runout. If the pilot is bent it must be replaced.

VALVE SEAT RECONDITIONING CONT'D

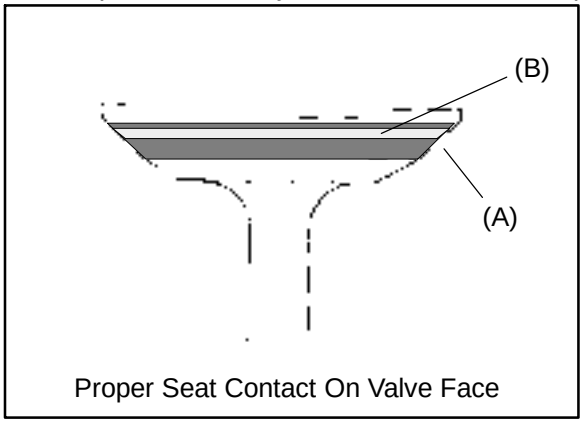
- If the contact area of the cutter is in the same place, the valve guide is distorted from improper installation.
- If the contact area of the initial cut is greater than 75%, continue to cut the seat until all pits are removed and a new seat surface is evident. **NOTE:** Remove only the amount of material necessary to repair the seat surface.

5. To check the contact area of the seat on the valve face, apply a thin coating of Prussian Blue t paste to the valve seat. If using an interference angle (46°) apply black permanent marker to the entire valve face (A).

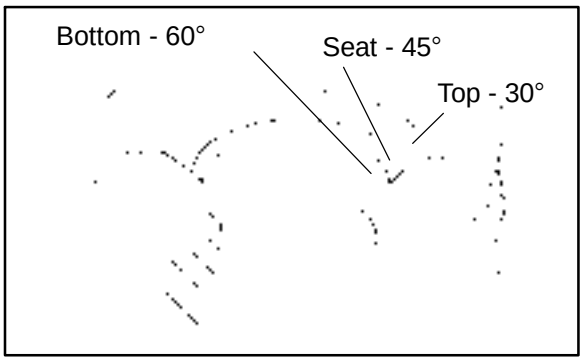


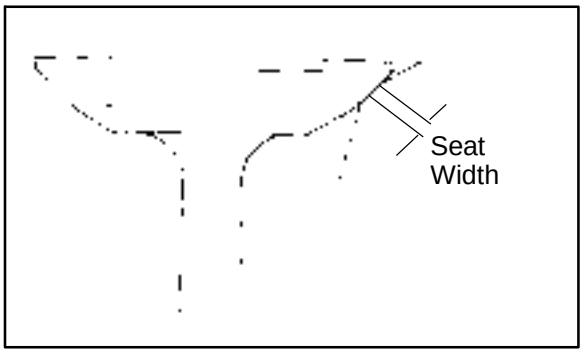
6. Insert valve into guide and tap valve lightly into place a few times.
7. Remove valve and check where the Prussian Blue t indicates seat contact on the valve face. The valve seat should contact the middle of the valve face or slightly above, and must be the proper width.
   - If the indicated seat contact is at the top edge of the valve face and contacts the margin area(B) it is too high on the valve face. Use the 30° cutter to lower the valve seat.
   - If too low, use the 60° cutter to raise the seat. When contact area is centered on the valve face, measure seat width.
   - If the seat is too wide or uneven, use both top and bottom cutters to narrow the seat.
   - If the seat is too narrow, widen using the 45° cutter and re-check contact point on the valve face and seat width after each cut.

NOTE: When using an interference angle, the seat contact point on the valve will be very narrow, and is a normal condition. Look for an even and continuous contact point all the way around the valve face. (B)



Proper Seat Contact On Valve Face





Valve Seat Width:

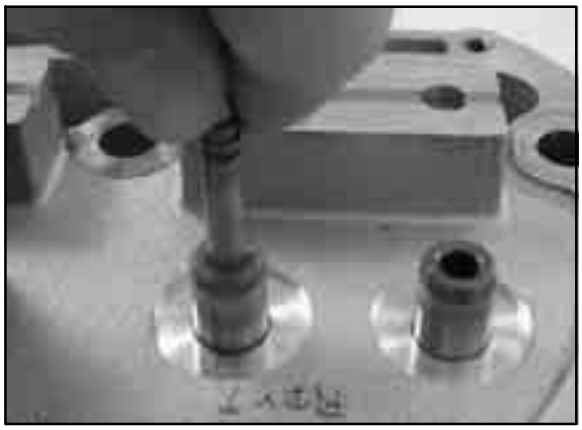
Intake Std: .047" (1.2 mm)
Limit: .055" (1.4 mm)
Exhaust Std: .059" (1.5 mm)
Limit: .071" (1.8 mm)

VALVE SEAT RECONDITIONING CONT"D

8. Clean all filings from the area with hot soapy water, rinse, and dry with compressed air.

> **⚠ WARNING**
>
> Wear eye protection or a face shield when working with compressed air during cylinder head disassembly and reassembly.

9. Lubricate the valve guides with clean engine oil, and apply oil or water based lapping compound to the face of the valve. **NOTE**: Lapping is not required with an interference angle valve job.
10. Insert the valve into its respective guide and lap using a lapping tool or a section of fuel line connected to the valve stem.

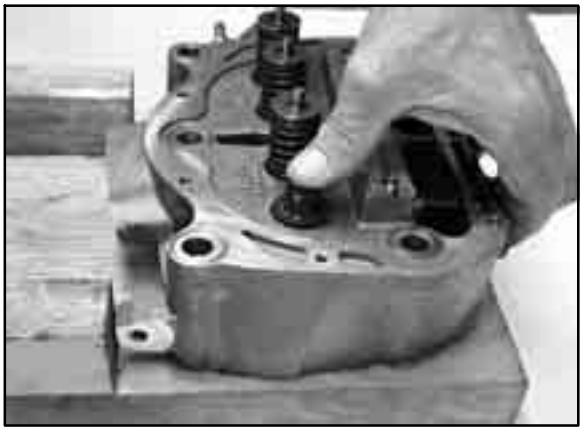


11. Rotate the valve rapidly back and forth until the cut sounds smooth. Lift the valve slightly off of the seat, rotate 1/4 turn, and repeat the lapping process. Do this four to five times until the valve is fully seated, and repeat process for the other valve(s).
12. Thoroughly clean cylinder head and valves.

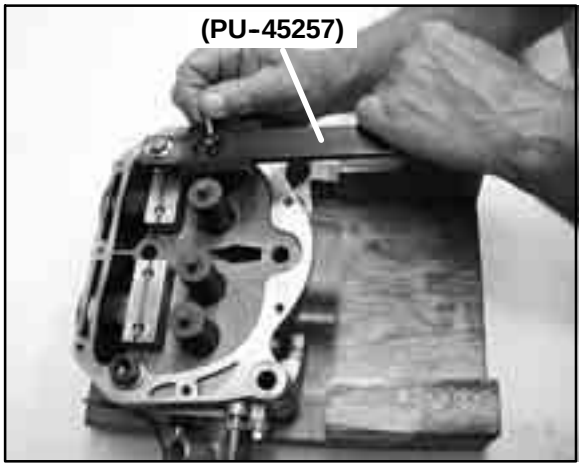
CYLINDER HEAD REASSEMBLY

NOTE: Assemble the valves one at a time to maintain proper order.

1. Apply engine oil to valve guides and seats.
2. Coat valve stem with molybdenum disulfide grease or 0W–40 Synthetic oil.
3. Install valve carefully with a rotating motion to avoid damaging valve seal.
4. Valve seals should be installed after the valves are in the head to avoid valve seal damage. Install new valve seals on valve guides.



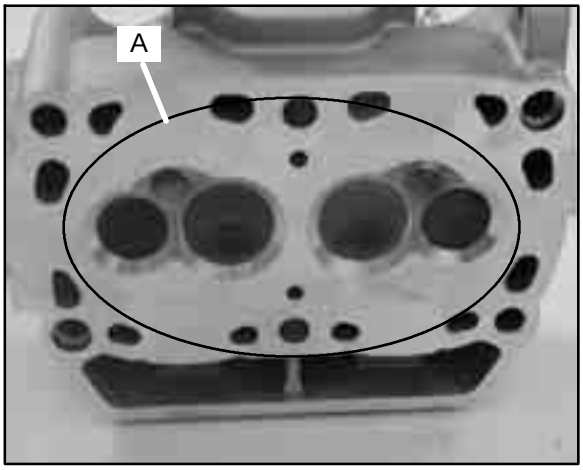
5. Dip valve spring and retainer in clean engine oil and install.
6. Place retainer on spring and install Valve Spring Compressor (**PU–45257**). Install split keepers with the gap even on both sides. NOTE: A small parts magnet can aid in installation of the keepers.



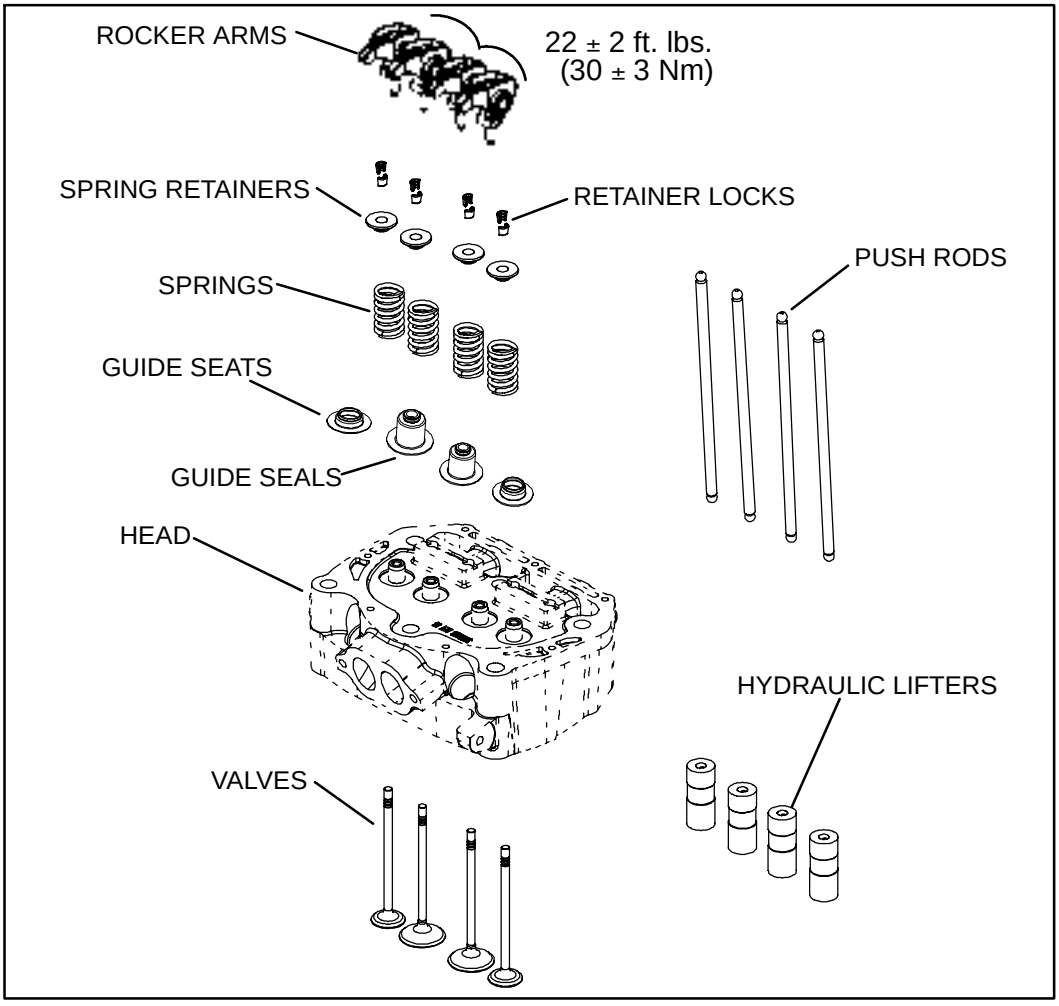
7. Repeat procedure for remaining valves. When all valves are installed, tap lightly with soft faced hammer on the end of the valves to seat the split keepers. **NOTE:** To prevent damage to the valve seals, do not compress the valve spring more than necessary to install the keepers.

VALVE SEALING TEST

1. Clean and dry the combustion chamber area (A). Refer to Page 3.25 for cleaning tips.
2. Pour a small amount of clean solvent onto the intake port and check for leakage around each intake valve. The valve seats should hold fluid with no seepage.
3. Repeat for exhaust valves by pouring fluid into exhaust port.



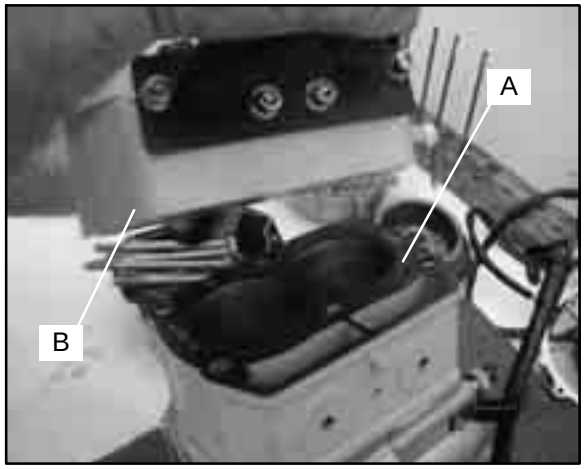
VALVE TRAIN EXPLODED VIEW



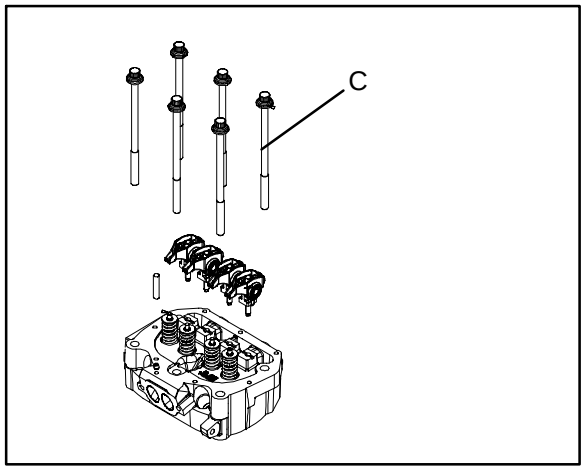
ENGINE HEAD REASSEMBLY

Before reassembly, clean the bolts and bolt holes with Primer N (**PN 2870585**) to remove any debris. This will ensure proper sealing when installing bolts.

1. Install the head gasket (A) on the cylinder (B).



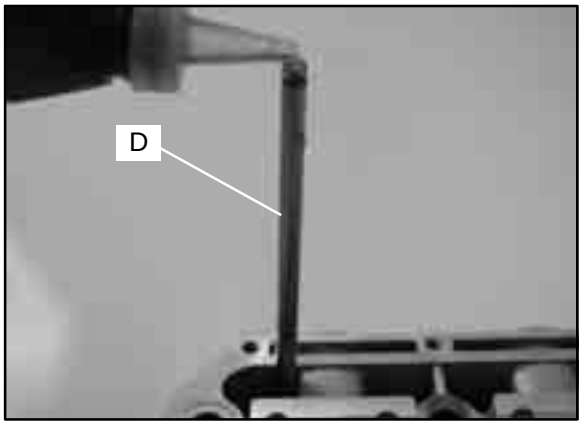
2. Install cylinder head on cylinder.
3. Lubricate threads and top of washers underside of bolt head with engine oil. Install head bolts (C). Torque to 35 ± 4 ft. lbs. (47.5 ± 5.5 Nm) in sequence provided (Pg.3.10). Allow the gasket to set for 1 minute at this torque, then turn bolts 90° (1/4 turn) in sequence . Refer to Page 3.10 for tightening sequence.



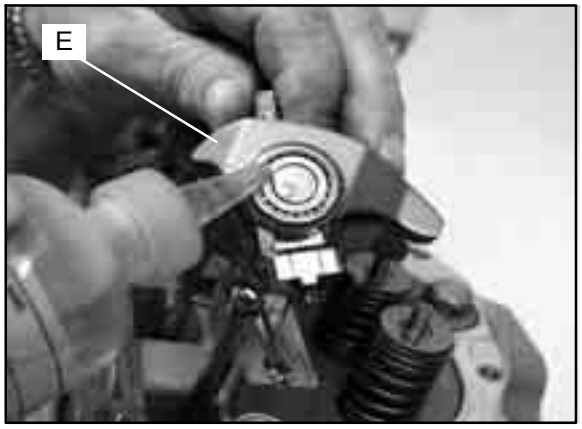
Cylinder Head Bolt Torque:

Torque in sequence to 15 ± 2 ft. lbs. (20.8 ± 2.7 Nm), allow the gasket to set for 1 minute, then back off 5 turns incrementally in sequence. Re-torque in sequence to 35 ± 4 ft. lbs. (47.5 ± 5.5 Nm). Finalize torque sequence by tightening each bolt an additional 90° (1/4 turn).

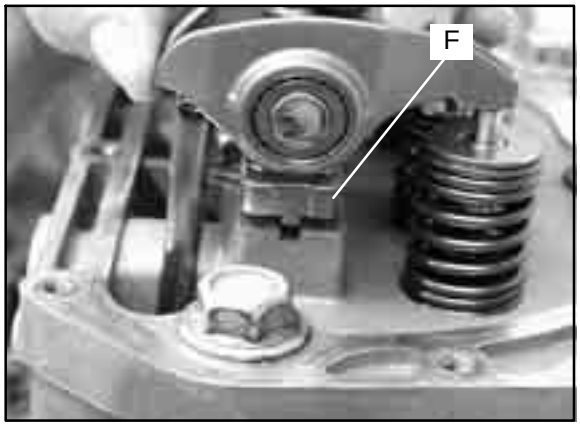
4. Apply assembly lube to push rods (D) and install into lifters.



5. Apply assembly lube to rockers (E).



6. Verify pushrods are engaged in lifters.
7. Install rockers. Be sure that tab of fulcrum (F) is seated in head stand-off. Torque bolts to 22 ± 2 ft. lbs. (30 ± 3 Nm).



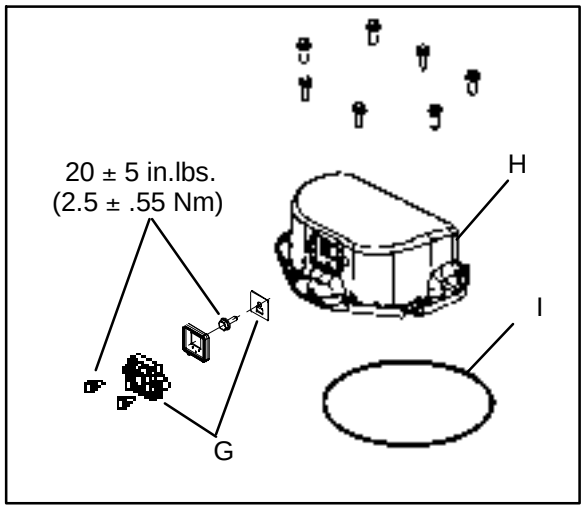
Rocker Arm Bolt Torque:
22 ± 2 ft. lbs.
(30 ± 3 Nm)

ENGINE HEAD REASSEMBLY CONT'D

8. Install breather plate and reed (G) into rocker cover (H). Lightly apply black RTV sealant to the outer edges of the breather reed. The reed has a tab and will assemble one way only. Torque the breather bolts to 20 ± 5 in. lbs. (2.5 ± 0.55 Nm).

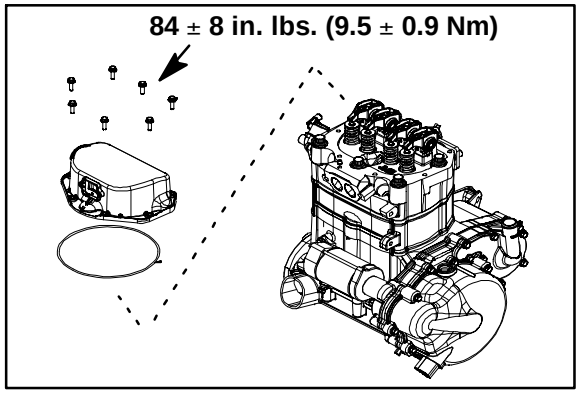
NOTE: When applying RTV, do not get any RTV inside the reed assembly.

9. Place a **new** seal (I) into the bottom of the cover. Be sure the seal is seated into the cover properly.



REMINDER: Before assembly, clean the bolts and bolt holes with Primer N (**PN 2870585**) to remove any debris. This will ensure proper sealing when installing bolts.

10. Install rocker cover. Torque bolts to 84 ± 8 in.lbs. (9.5 ± 0.9 Nm). See Page 3.6 for proper torque sequence.

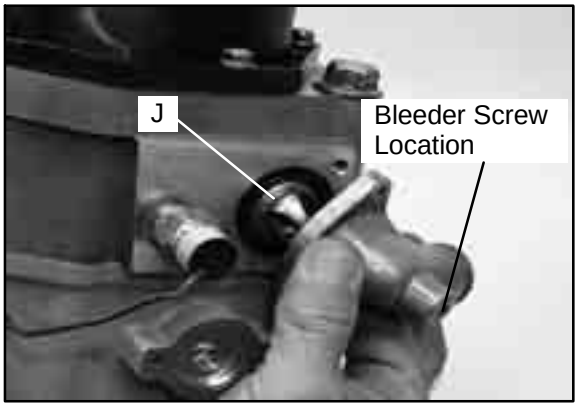


Rocker Cover Bolt Torque:

84 ± 8 in. lbs. (9.5 ± 0.9 Nm)

***Torque In Proper Sequence (Pg. 3.6)**

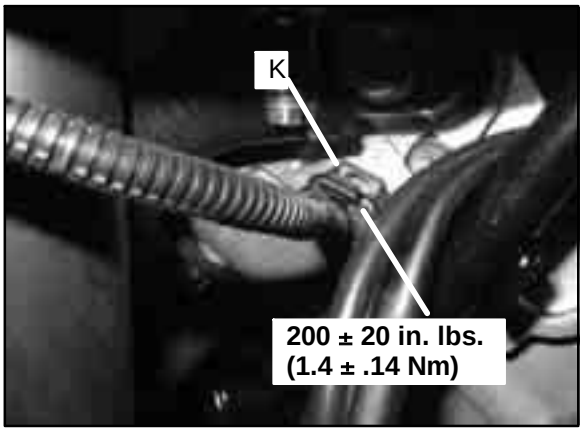
11. Install thermostat (J), new O-ring, and thermostat housing. Torque thermostat housing bolts to 84 ± 8 in.lbs. (9.5 ± 0.9 Nm). Install bleeder screw if previously removed.

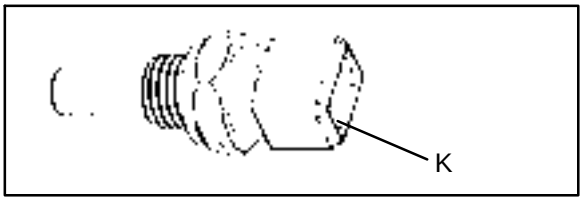


Thermostat Housing Bolt Torque:
84 ± 8 in. lbs. (9.5 ± 0.9 Nm)

Thermostat Housing Bleeder Screw:
70 ± 10 in. lbs. (8 ± 1.13 Nm)

12. Install and torque to 200 ± 20 in. lbs. (1.4 ± .14 Nm). (K) See Pg. 3.6 for placement.

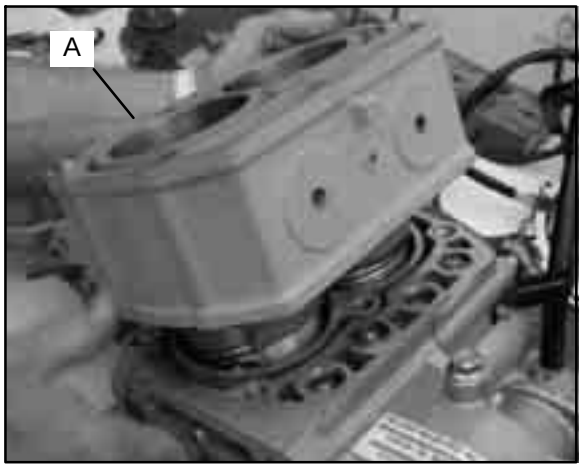




Temperature Sender Torque:
200 ± 20 in. lbs. (1.4 ± .14 Nm)

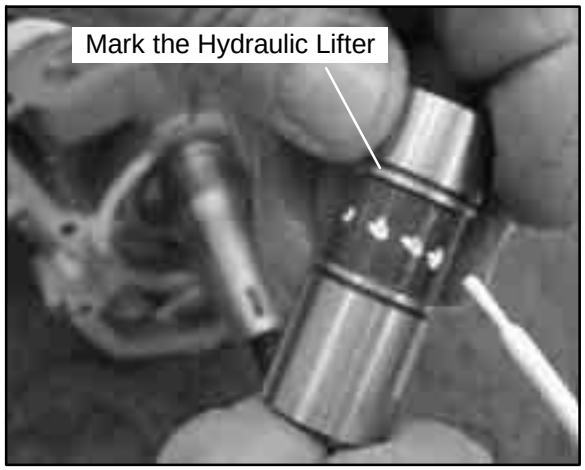
CYLINDER REMOVAL

1. Follow engine disassembly procedures to remove rocker cover and cylinder head.
2. Tap cylinder (A) lightly with a rubber mallet in the reinforced areas only until loose.
3. Rock cylinder forward and backward while lifting it from the crankcase, supporting pistons and connecting rods. Support pistons with Piston Support Block (**PN 2870390**).

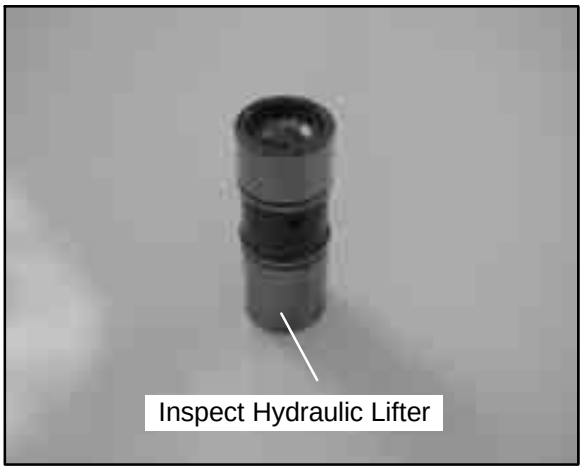


VALVE LIFTER REMOVAL/INSPECTION

1. Remove the valve lifter's by reaching into the crankcase and pushing the lifter up through the lifter bore by hand.
2. Thoroughly clean the lifters in cleaning solvent and wipe them with a clean lint-free cloth.
3. Mark the lifters with a white pen if using the lifters for reassembly. This will ensure that the lifters are properly placed during engine reassembly.



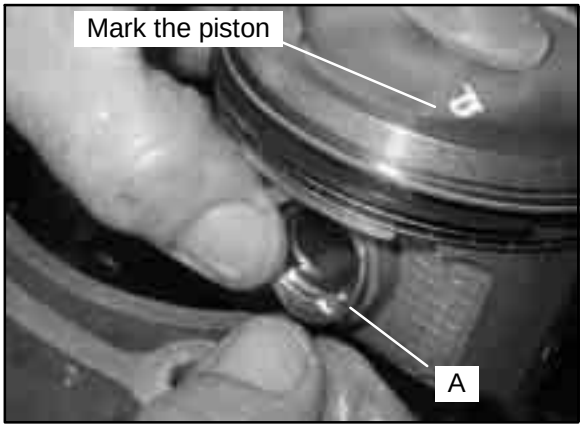
4. Check the lifters for wear or scores.
5. Check the bottom end of lifter to make sure that it has a slight convex.
6. If the bottom surface has worn flat, it may be used with the original camshaft only.



NOTE: Lifters that are scored, worn, or if the bottom is not smooth should be replaced with new lifters and cam as an assembly. If replacing the lifters, the camshaft should also be replaced.

PISTON REMOVAL

1. Remove circlip (A). Mark the piston with a white pen to ensure proper orientation (if reused) during assembly.



NOTE: If the pistons are to be reused, reassemble the pistons in the same cylinder and direction from which they were removed.

NOTE: New pistons are non-directional and can be placed in either cylinder.

2. Remove piston circlip and push piston pin out of piston. If necessary, heat the crown of the piston *slightly* with a propane torch. **CAUTION:** Do not

apply heat to the piston rings. The ring may lose radial tension.

3. Remove top compression ring:

***Using a piston ring pliers**: Carefully expand ring and lift it off the piston. **CAUTION:** Do not expand the ring more than the amount necessary to remove it from the piston, or the ring may break.

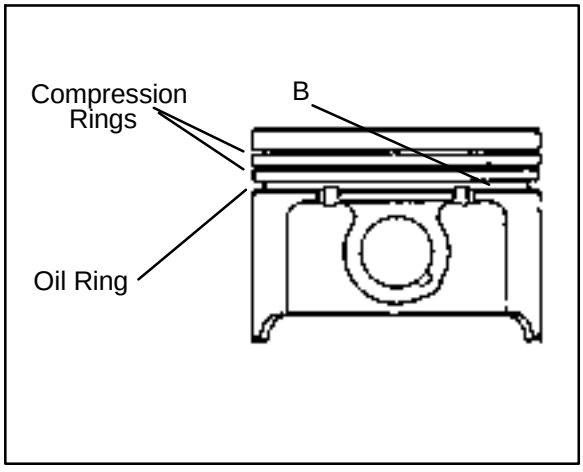
***By hand:** Placing both thumbs as shown, spread the ring open and push up on the opposite side. Do not scratch the ring lands.

4. Repeat procedure for second ring.
5. Remove the oil control ring.

The oil control ring is a three piece design consisting of a top and bottom steel rail and a center expander section. The top rail has a locating tab on the end which fits into a notch (B) in the upper oil ring land of the piston. To Remove:

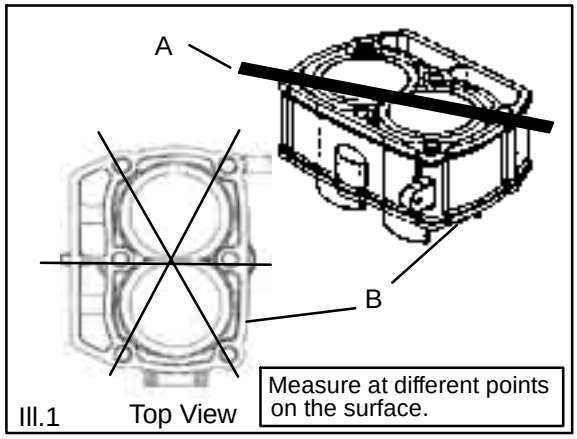
a) Remove the top rail first followed by the bottom rail.

b) Remove the expander.

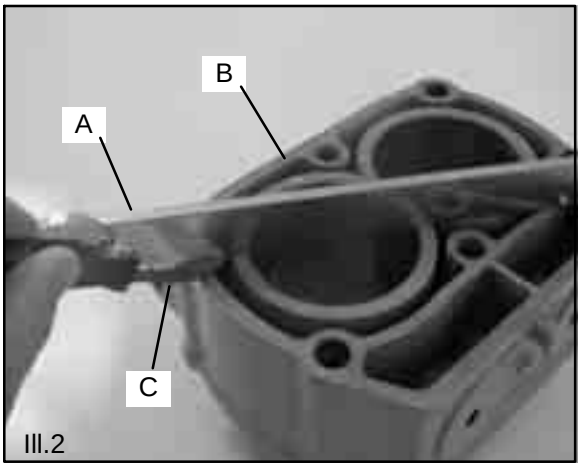


CYLINDER INSPECTION

1. Remove all gasket material from the cylinder sealing surfaces.
2. Inspect the top of the cylinder (B) for warpage using a straight edge (A) and feeler gauge (C). Refer to Ill. 1 and Ill. 2.



Ill.1 Top View

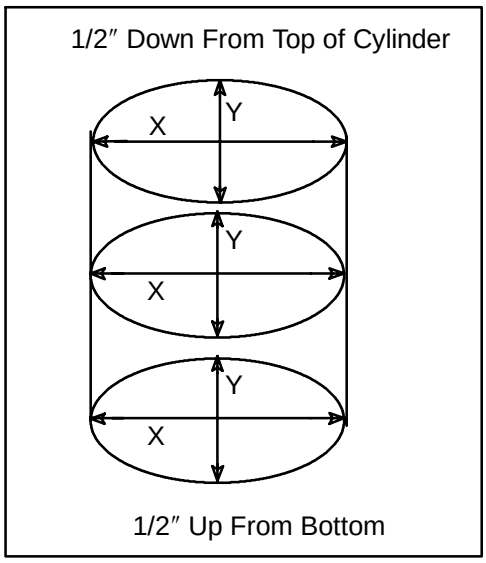


Ill.2

Cylinder Warpage.

.004″ (0.1 mm) Max.

3. Inspect cylinder for taper and out of round with a telescoping gauge or a dial bore gauge. Measure in two different directions, front to back and side to side, on three different levels (1/2″ down from top, in the middle, and 1/2″ up from bottom).



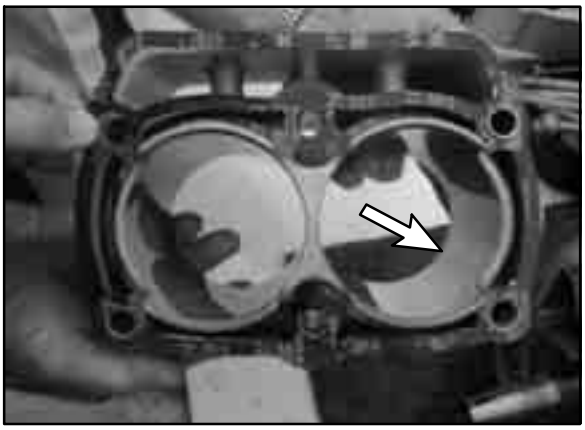
4. Record measurements. If cylinder is tapered or out of round beyond .002, the cylinder must be replaced.

Cylinder Taper
Limit: .002" (.05mm)Max.
Cylinder Out of Round
Limit: .002" (.05mm)Max.

Standard Bore Size (Both Cylinders):

700 : 3.1496" (80 mm)

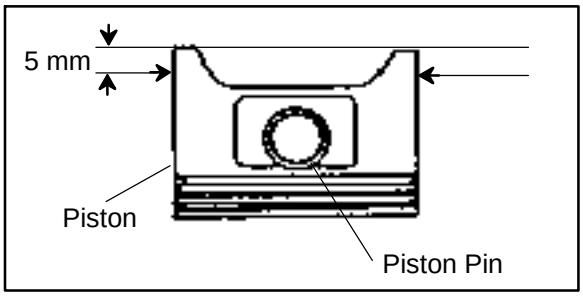
5. Inspect cylinder for wear, scratches, or damage.



PISTON-TO-CYLINDER CLEARANCE

Measure piston outside diameter at a point 5 mm up from the bottom of the piston at a right angle to the direction of the piston pin.

Subtract this measurement from the maximum cylinder measurement obtained in Step 5.



Piston to Cylinder Clearance

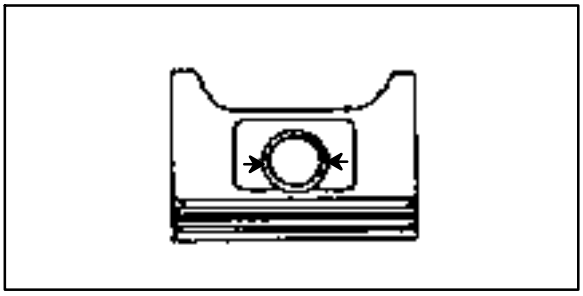
700: .0016" ± .00063" (.041 ± .016 mm)

Piston O.D.

700: 3.1477" ± .00012" (79.954 ± .003 mm)

PISTON/ROD INSPECTION

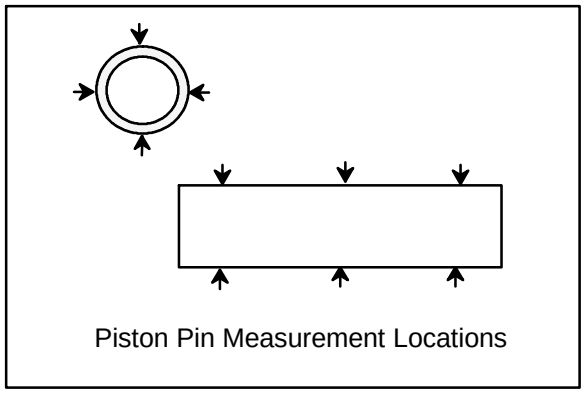
1. Measure piston pin bore.



Piston Pin Bore:

700: 0.00059" ± 0.0002"
(0.015 ± 0.005 mm)

2. Measure piston pin O.D. Replace piston and/or piston pin if out of tolerance.

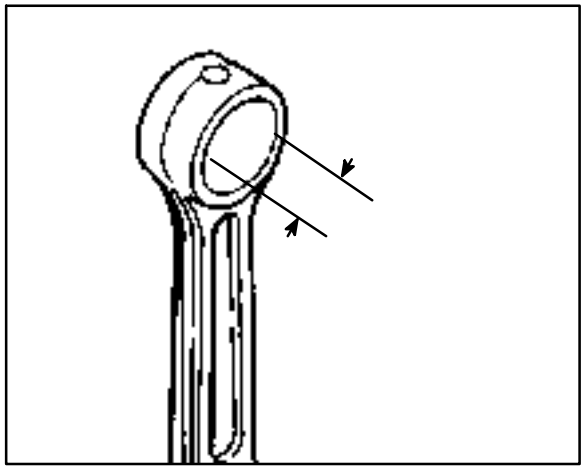


Piston Pin Measurement Locations

Piston Pin O.D.

0.7874" – .7872" (20 – 19.995 mm)

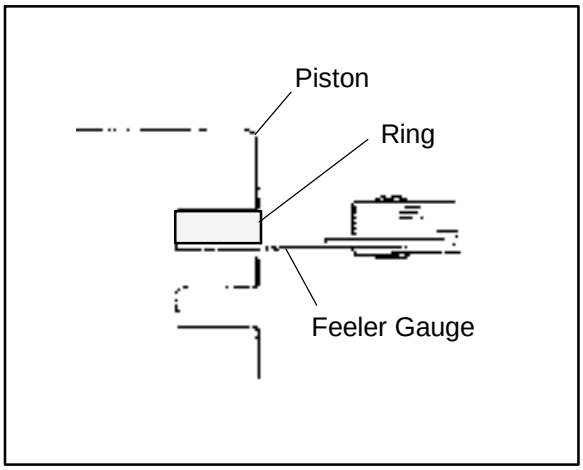
3. Measure connecting rod small end ID.



Connecting Rod Small End I.D.

.789" – .78841". (20.030 – 20.015 mm)

4. Measure piston ring to groove clearance by placing the ring in the ring land and measuring with a thickness gauge. Replace piston and rings if ring-to-groove clearance exceeds service limits.

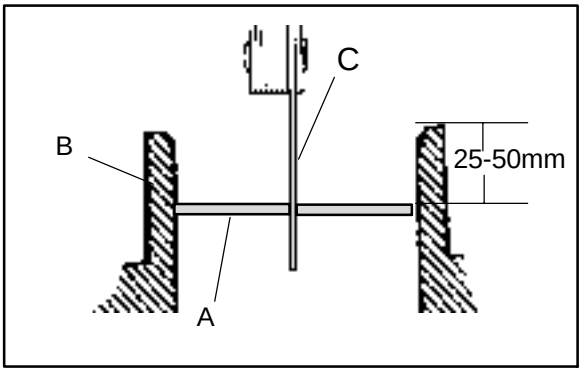


Piston Ring-to-Ring Groove Clearance

Top Ring Limit: 0.0019" ± 0.00069"
(0.0475 ± 0.0175 mm)
Second Ring Limit : 0.0017" ± 0.00049"
(0.0425 ± .0125 mm)

PISTON RING INSTALLED GAP

1. Place each piston ring (A) inside cylinder (B) using piston to push ring squarely into place as shown. (See next page)



Piston Ring Installed Gap:

700

Top Ring Limit: 0.01083" ± 0.00295"
(0.275 ± 0.075 mm)
Second Ring Limit: 0.0177" ± 0.00394"
(0.45 ± 0.10 mm)
Oil Ring Limit: 0.0177" ± .00984"
(0.45 ± 0.25 mm)

NOTE: Ring should be installed with the mark on the ring facing upward.

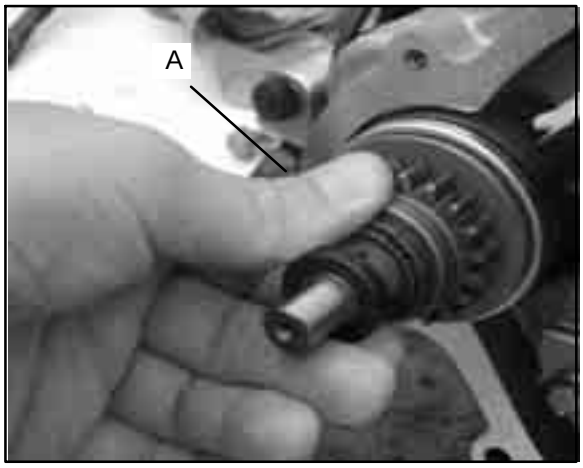
2. Measure installed gap with a feeler gauge (C) at both the top and bottom of the cylinder. **REMINDER:** A difference in end gap indicates cylinder taper. The cylinder should be measured for excessive taper and out of round.
3. If the *bottom* installed gap measurement exceeds the service limit, replace the rings. If ring gap is smaller than the specified limit, file ring ends until gap is within specified range.

NOTE: Always check piston ring installed gap after re-boring a cylinder or when installing new rings. A re-bored cylinder should always be scrubbed thoroughly with hot soapy water, rinsed, and dried completely. Wipe cylinder bore with oil immediately to remove residue and prevent rust.

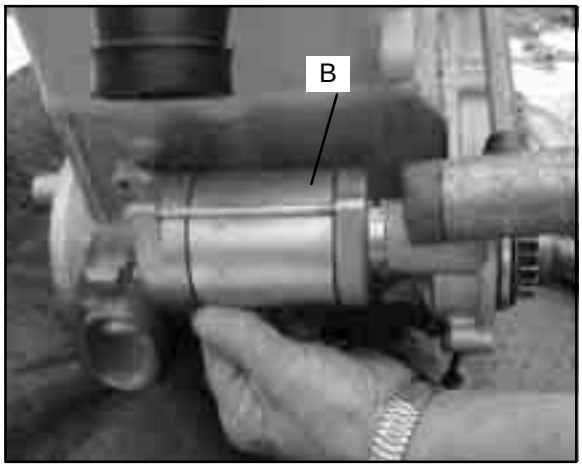
NOTES

STARTER DRIVE/BENDIX REMOVAL/INSPECTION

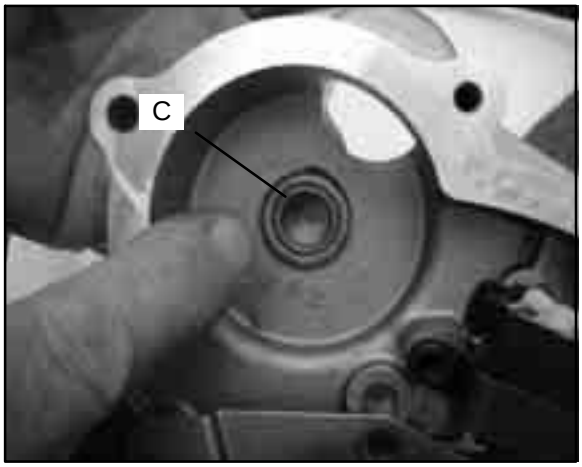
1. Remove stator housing bolts and remove housing.
2. Remove the flywheel nut and washer. Install Flywheel Puller (**PN 2871043**) and remove flywheel. **CAUTION:** Do not thread the puller bolts into the flywheel more than 1/4″ or stator coils may be damaged.
3. Remove starter bendix assembly (A). Note the thrust washers located on both sides of the bendix.



4. Inspect the thrust washer for wear or damage and replace if necessary.
5. After the bendix is removed, tap on the starter assembly (B) with a soft faced mallet to loosen the starter from the crankcase.

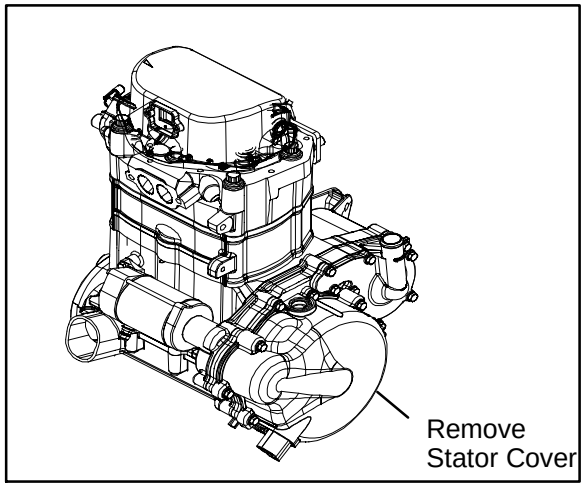


6. Inspect gear teeth on starter drive (B). Replace starter drive if gear teeth are cracked, worn, or broken.
7. Inspect the bendix bushing (C) in the mag cover for wear. Replace as needed.

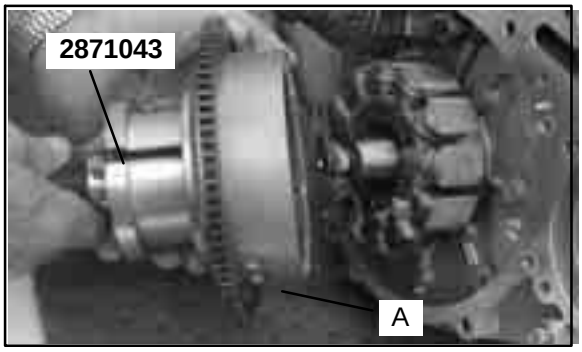


FLYWHEEL/STATOR REMOVAL/INSPECTION

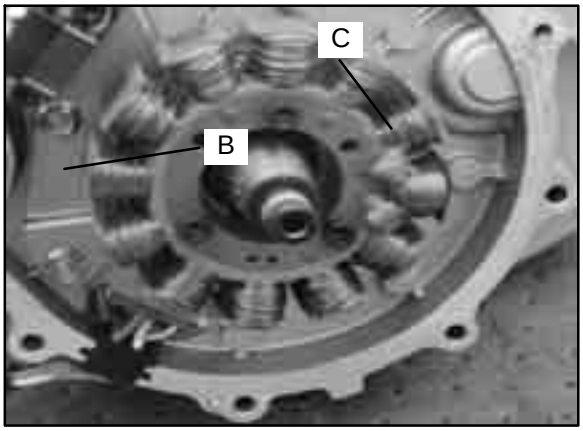
1. Remove stator housing bolts and remove housing.



2. Remove flywheel nut and washer.
3. Install Flywheel Puller (**PN 2871043**) and remove flywheel (A). **CAUTION:** Do not thread the puller bolts into the flywheel more than 1/4″ or stator coils may be damaged.



4. Use caution when removing the wire holddown (B) and the stator assembly (C). **Do not tap or bump the gear /stator housing cover or the stator**. This could cause the seal around the gear/stator housing cover and the crankcase to break, causing a leak.

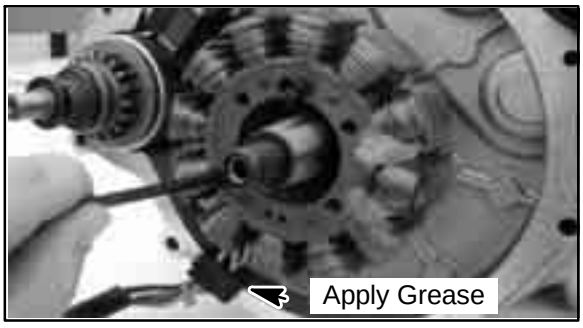


5. Remove the bendix if necessary.

FLYWHEEL/STATOR INSTALLATION

NOTE: Before assembly, clean the bolts and bolt holes with Primer N (**PN 2870585**) to remove any debris. This will ensure proper sealing when installing bolts.

1. Carefully install the stator and trigger coil to the gear/stator housing cover. **Do not tap on the stator or the gear stator housing cover.** This may cause a leak in between the gear/stator housing cover and the crankcase.
2. Properly place the stator wires under the wire holddown and install the bolts. Inspect the bolts, if new bolts are needed, replace them with new bolts. The new bolts contain patch lock, so Loctite t is not needed on the new bolts. Torque bolts to 96 ± 12 in.lbs. (10.85 ± 0.35 Nm). Apply a corrosion resistant grease to the rubber grommet to help keep contaminants from entering the stator area.



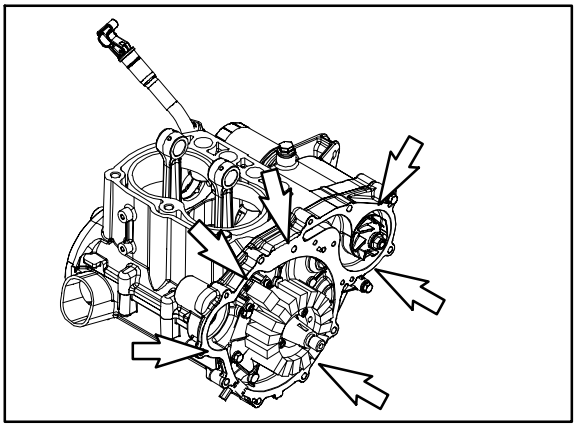
3. Install the starter bendix if removed.

4. Install woodruff key. Install the flywheel. Install the flywheel washer and nut. Torque the flywheel nut to 65 ± 7 ft.lbs. (88 ± 9.50 Nm)

Flywheel Nut Torque:

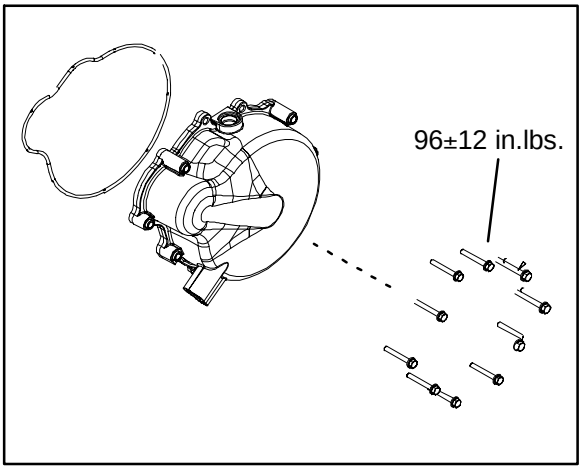
65 ± 7 ft. lbs. (88 ± 9.50 Nm)

5. Inspect the mating surface around the gear/stator housing cover and the crankcase for oil seepage. If there is seepage between the mating surfaces, then the gear/stator housing cover must be resealed. Clean the gearcase surfaces and reseal with a new gasket. Refer to the Lower Engine Disassembly section and the Lower Engine Assembly section for details. Inspect the areas pointed out in the illustration for possible oil seepage.



FLYWHEEL/STATOR INSTALLATION

6. Install stator housing with new O-rings. Torque the bolts to 96 ± 12 in. lbs. (1.85 ± 1.35 Nm). Follow bolt torque sequence on Pg. 3.4.



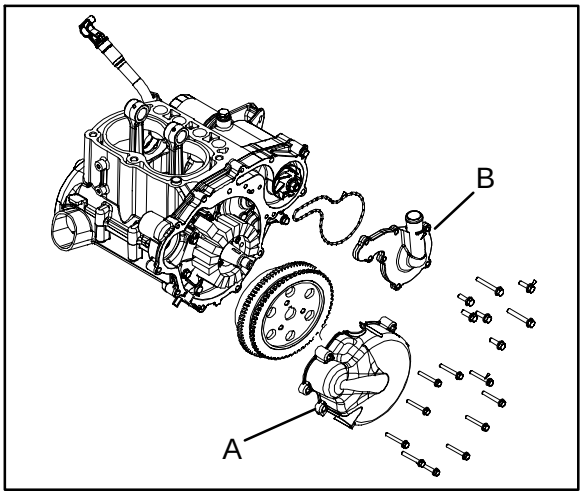
***Stator Housing Bolt Torque:**

96 ± 12 in.lbs. (1.85 ± 1.35 Nm)

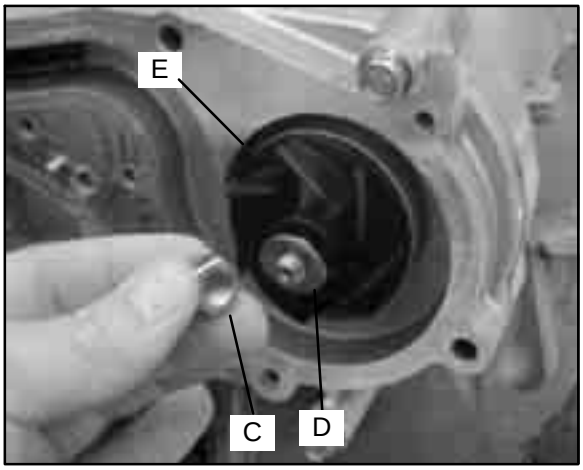
***Torque Bolts In Sequence (Pg. 3.4)**

ENGINE CRANKCASE DISASSEMBLY/INSPECTION

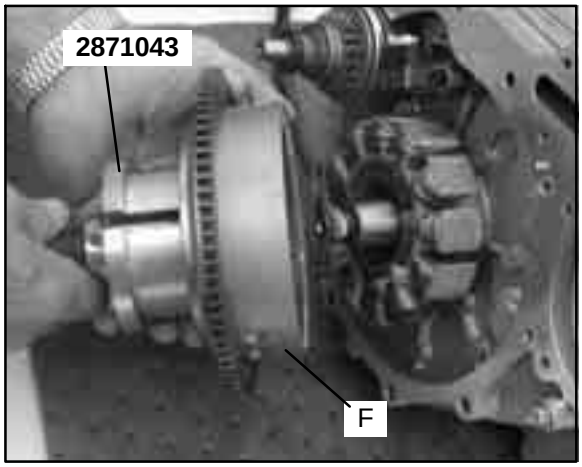
1. Remove the stator cover (A) and water pump cover (B).



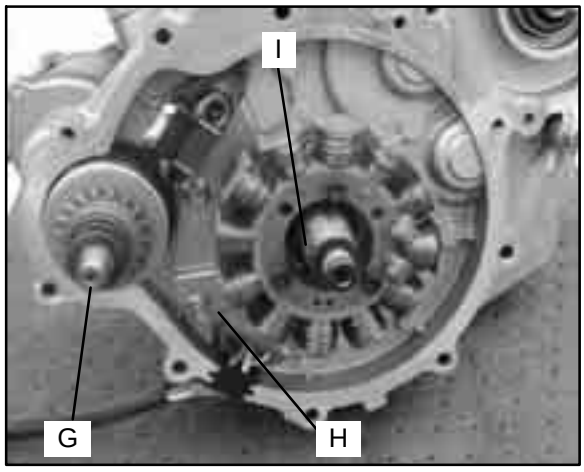
2. Remove the nylok nut (C), washer (D), and water pump impeller (E). Remove part of the water pump seal behind the impeller.



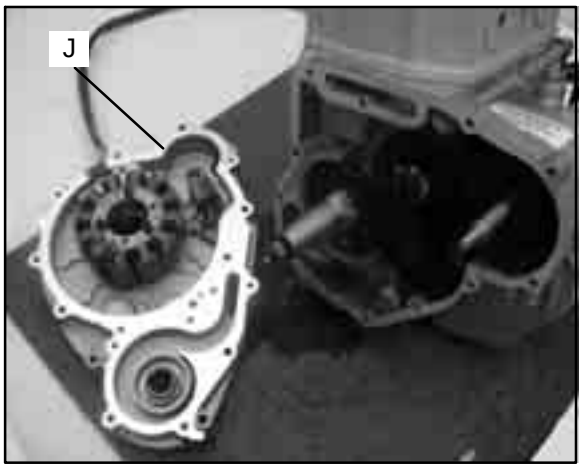
3. Remove flywheel nut and washer.
4. Install Flywheel Puller (**PN 2871043**) and remove flywheel (F). **CAUTION:** Do not thread the puller bolts into the flywheel more than 1/4″ or stator coils may be damaged.



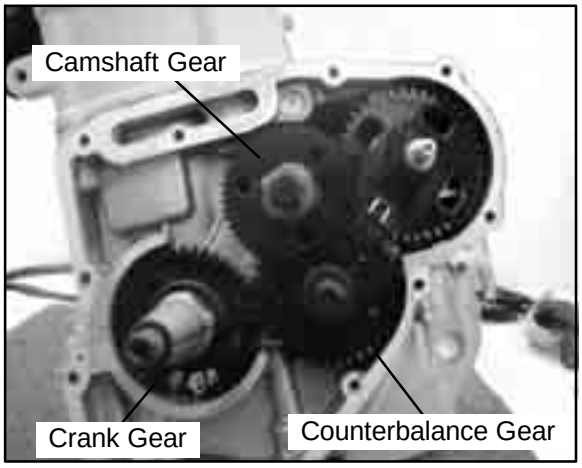
5. Remove the starter bendix (G), wire holddown plate (H), and the woodruff key (I) from the crankshaft. The stator does not have to be removed at this point.



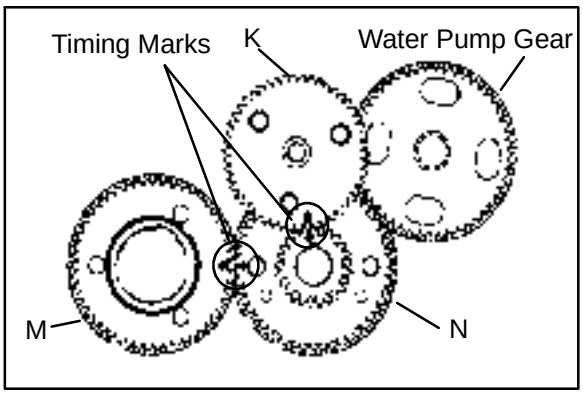
6. Remove the gear/stator housing bolts and remove the gear/stator housing cover (J) and gasket from the crankcase. Be sure to catch the excess oil from the crankcase.



7. Note the positions of the gears in the photo.



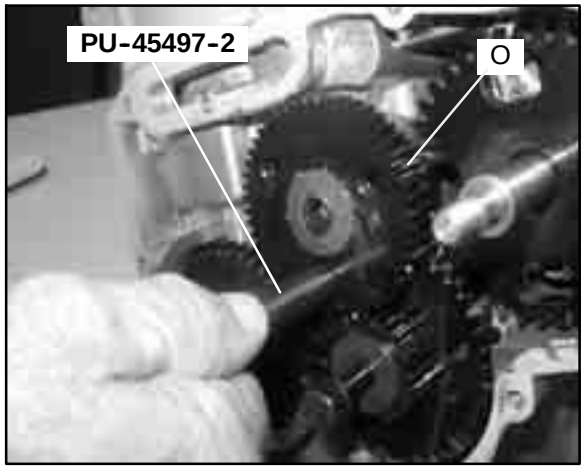
8. Use a white pen to accent the timing marks on the following gears: camshaft gear (K), crankshaft gear (M), or counterbalance gear (N) This will ensure proper gear alignment and timing during reassembly of the gears.



NOTE: If replacing one of the gears, it is recommended that all of the gears be replaced. A gear kit is available in the parts book.

Cam Gear Removal

9. Use the Cam Gear Tooth Alignment Tool (**PU-45497-2**) (O) to align the cam split gear assembly. With the split gear aligned, remove the bolt and cam gear assembly.



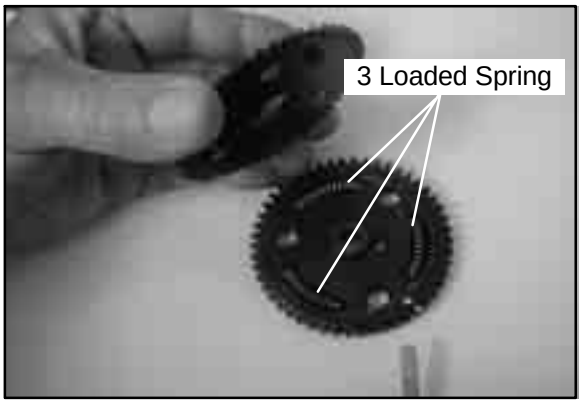
NOTE: Install the Cam Gear Tooth Alignment Tool (**PU-45497-2**) into the assembly hole counter clockwise from the timing mark as shown.

Cam Gear Alignment Tool:

(PU-45497-2)

Cam Gear Disassembly

10. Inspect the cam gear teeth and check to make sure there is spring tension offsetting the teeth between the two gears. If there is no tension, check the springs inside of the cam gear assembly.

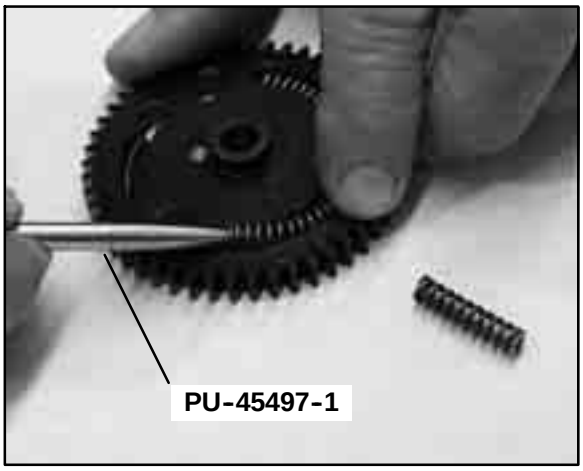


11. The cam gear assembly contains three loaded springs. To open the cam gear assembly:
    - Place the cam gear on a flat surface with the timing mark side facing up.
    - While holding both gears together, lightly work a small flathead screwdriver between the two gears.
    - Remove the top gear. The springs should stay in place.

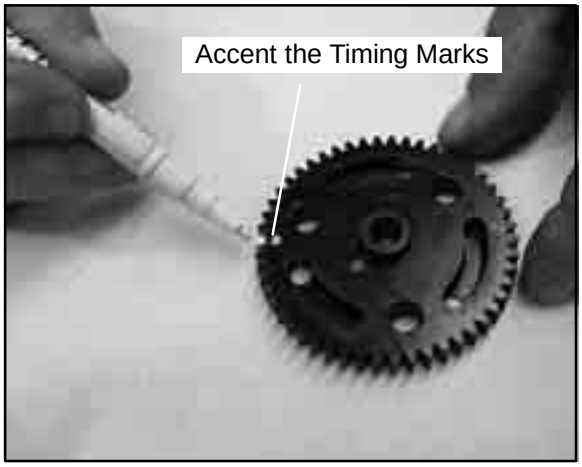
CAUTION:

WEAR SAFETY GLASSES AT ALL TIMES. USE CAUTION WHEN WORKING WITH THE TOP GEAR. THE SPRINGS COULD CAUSE INJURY OR BECOME LOST SHOULD THEY POP OUT.

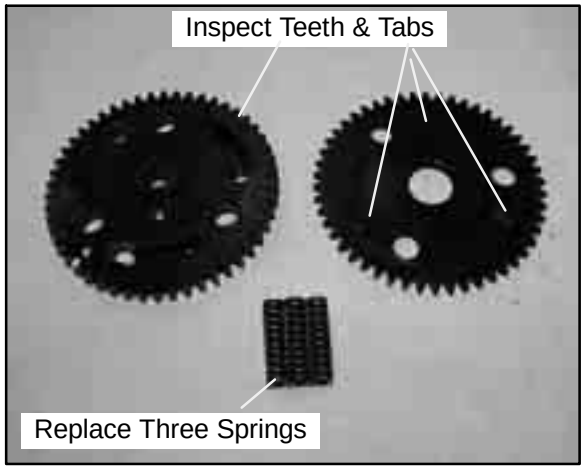
12. Remove all three springs using one of the tapered pins from the Tapered Pins (**PU-45497-1**).



13. With a white marking pen, accent the timing mark on the gear that contains the springs.

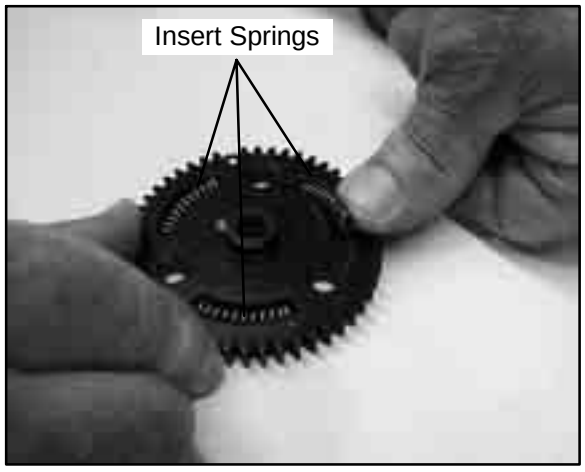


14. Inspect the gear teeth and the three tabs on the gears for wear.

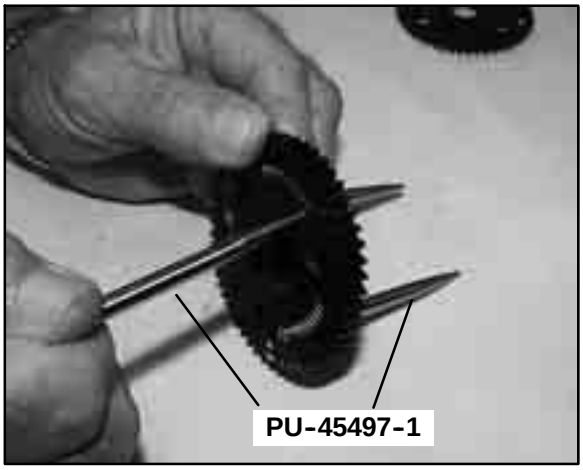


Cam Gear Reassembly

15. Install the new springs into the grooves of the cam gear.



16. Insert the pointed dowels from the Tapered Pins (**PU-45497-1**) into the cam gear.

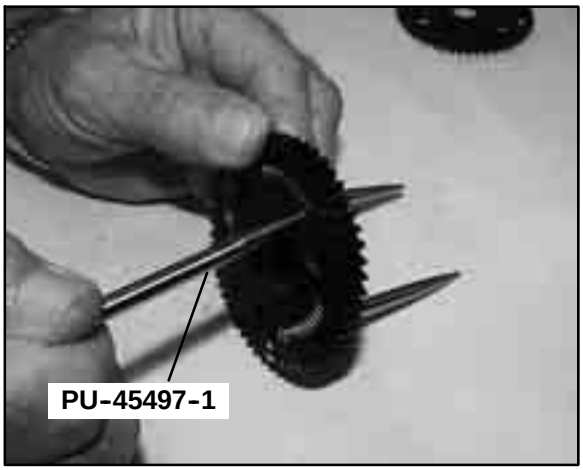


To assemble:

- Hold the spring with one finger.
- Start the pointed end of the tapered pin into the cam gear hole and slowly push the dowel through the hole until the end of the dowel is almost flush with the spring.
- Perform this procedure with all three tapered pins.
- **Do not push the pins too far through or the springs will pop out.**

NOTE: Do not remove the tapered pins at this time.

17. Note in the photograph that the Tapered Pins (**PU-45497-1**) are below flush with end of the springs. This helps to align the three gear tabs during the next step.

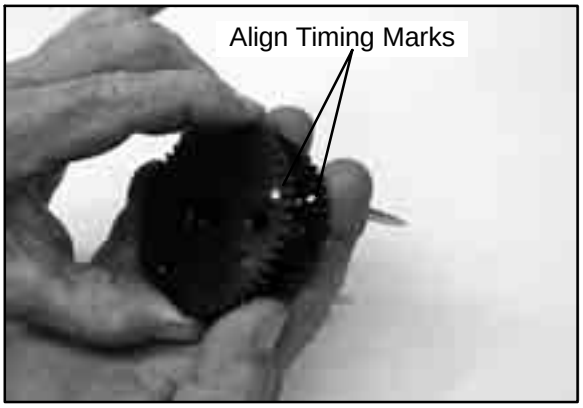


Cam Gear Spring Installation Tool Kit:
(PU-45497)

Tapered Pins:
(PU-45497-1)

Cam Gear Tooth Align Tool:
(PU-45497-2)

18. Line up the two gears using the timing marks and the three gear tabs that were referenced earlier. Push the gears back together, using both hands and hold securely.



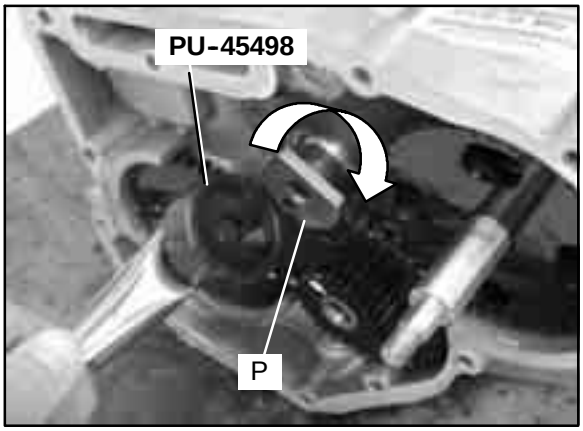
19. Once the gears are pressed together, firmly hold the gears together with one hand. Carefully remove the Tapered Pins (**PU-45497-1**) by pulling them out one at a time with the other hand.

20. After the tapered pins are removed, be sure the cam gear assembly is held together tightly. Place the cam gear assembly on a flat surface. Use the Cam Gear Tooth Alignment Tool (**PU-45497-2**) (R) to align the teeth of the cam gears, as shown in the picture.

NOTE: Install the Cam Gear Alignment Tool (**PU-45497-2**) into one assembly hole counter clockwise from the timing mark.

NOTE: For ease of installing the Cam Gear Alignment Tool (**PU-45497-2**) (R), use a twisting motion when pushing down on the tool.

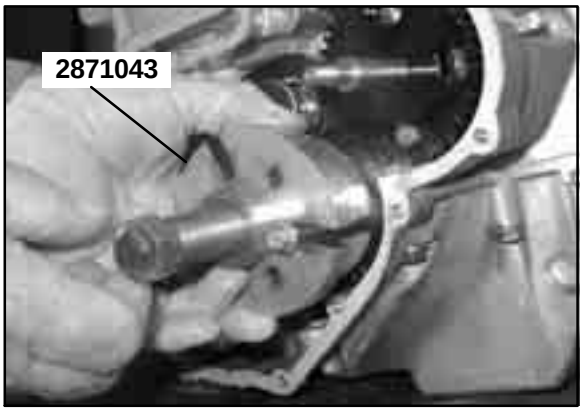
21. To remove the balance shaft gear, the flat side of the camshaft (P) must face the balance shaft gear. To rotate the camshaft, use the Cam Spanner Wrench (**PU-45498**) to rotate the camshaft so the flat side of the camshaft faces the balance shaft gear.



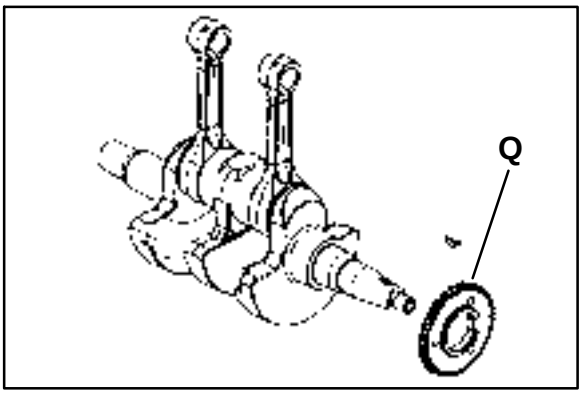
NOTE: This Cam Spanner Wrench (**PU-45498**) is only needed to rotate the camshaft when the entire valve train is assembled. If the rocker arms are removed, the camshaft can be turned by hand.

22. Remove the bolt and nut from the balance shaft gear. Try to remove the balance shaft gear. If the gear does not come off manually, use the Flywheel Puller (**PN 2871043**) to remove the

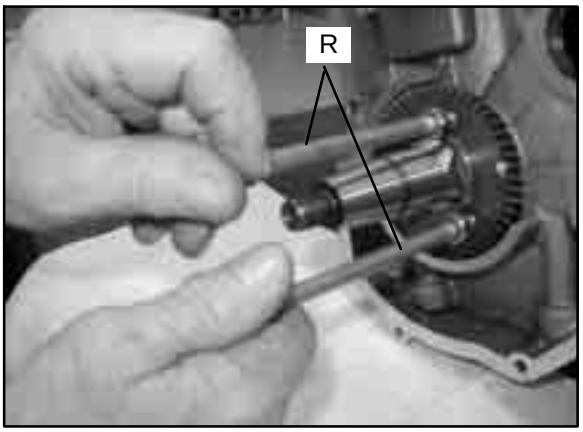
balance shaft gear.



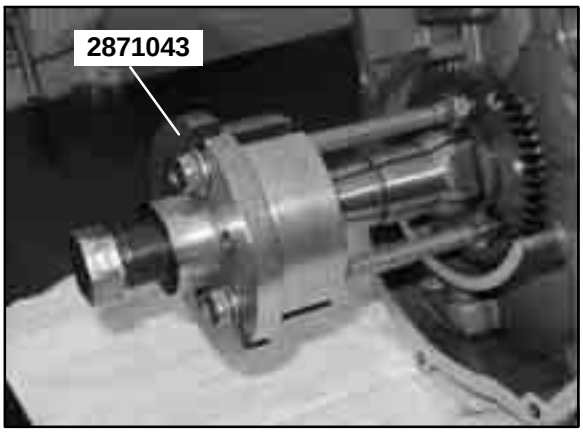
23. Inspect the crankshaft gear (Q) for broken or worn teeth. **If the crankshaft gear does not need to be replaced, it does not need to be removed**. If the crankshaft gear is damaged, remove the crankshaft gear with the Flywheel Puller (**PN 2871043**).



24. Install the two puller bolts (R). Tighten the puller bolts up so that the bolts are at equal length.

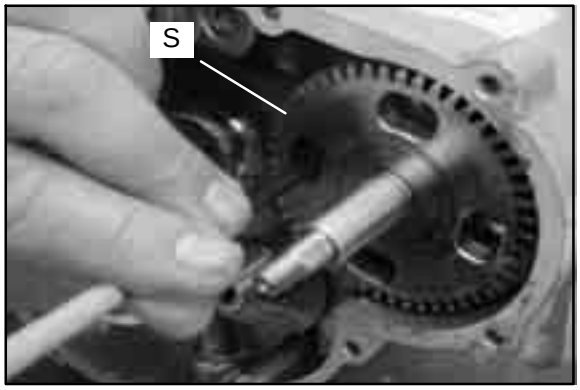


25. Install the Flywheel Puller (**PN 2871043**) and remove the crankshaft gear, if needed.



Water/Oil Pump Removal/Disassembly

26. Rotate the water/oil pump gear (S), so that all four bolts are visible though the gear. Remove the four bolts with a hex wrench. Pull out the pump.

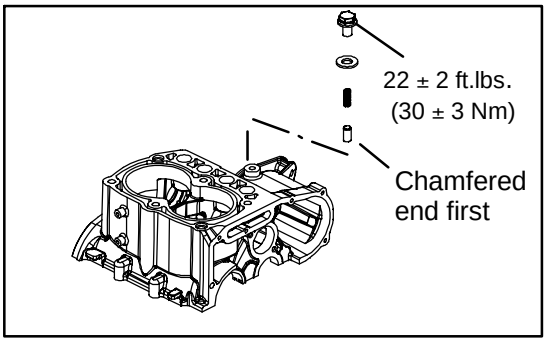


27. Inspect the oil pump rotors for wear. Mark the rotors with a white pen to ensure upon reassembly that the correct sides of the rotors are installed and mesh with the same edges as previously installed.

NOTE: If replacing the old rotors, new replacement rotors will fit into the old oil/water pump housing.

28. Remove the oil pressure relief. The oil pressure relief consists of a bolt, washer, spring, and valve (dowel). Inspect the the valve (dowel) for signs of possible obstructions. Use compressed air to blow out any debris.

29. Reinstall the valve (dowel chamfered end first). Install the spring, washer, and bolt. Torque the bolt to 22 ± 2 ft. lbs. (30 ± 3 Nm).

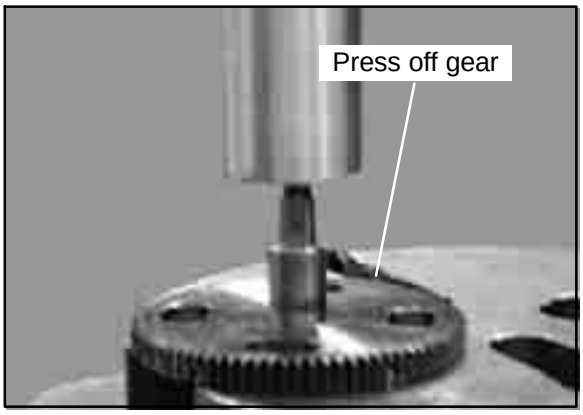


NOTE: Be sure to place the tapered end of the valve (dowel) in first. If the valve is installed incorrectly, oil pressure and oil priming problems will occur.

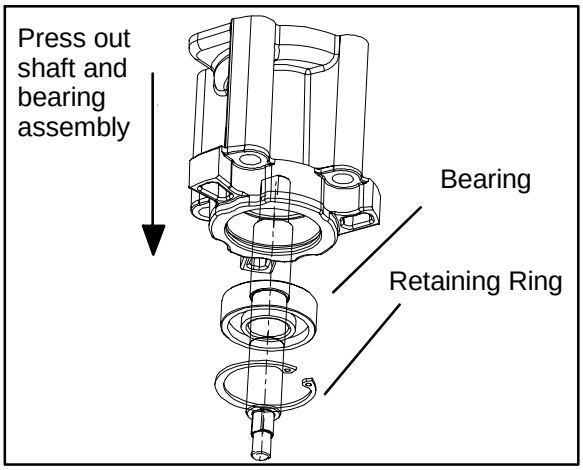
DISASSEMBLY OF WATER/OIL PUMP SHAFT

⚠ WARNING **Wear appropriate safety gear during this procedure. Protective gloves, clothing and eyewear are required.**

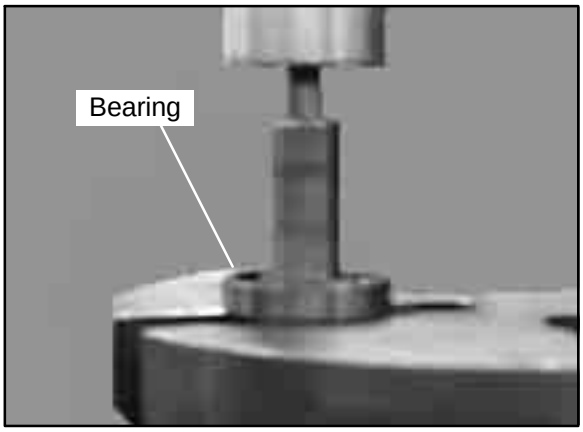
30. Carefully press the gear off the assembly while supporting the housing assembly.



31. Remove the snap ring from the assembly. Place the housing in a support and press out the bearing/shaft assembly.

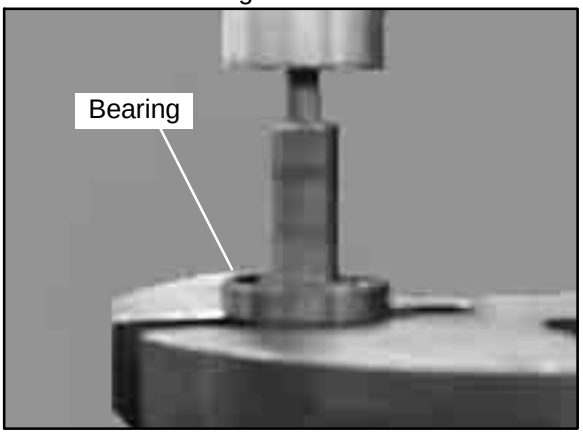


32. Place the shaft in a press to remove the bearing.

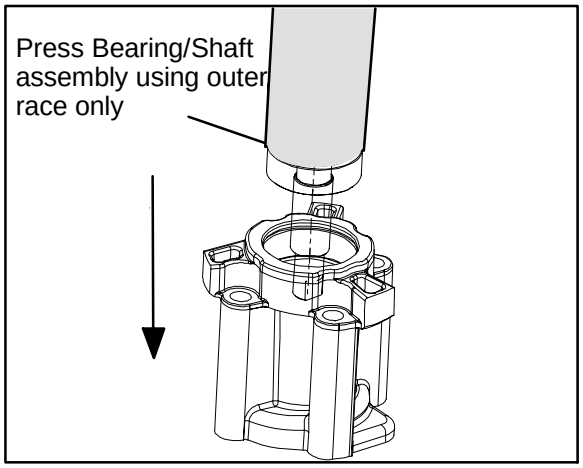


WATER/OIL PUMP REASSEMBLY

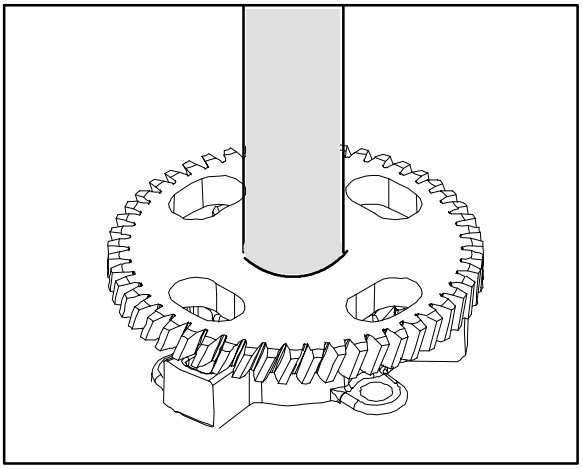
33. Press new bearing onto the shaft.



34. Press the bearing/shaft assembly using the bearing's outer race. *Do not use the shaft to press the assembly into the housing, as bearing damage may result.* Install retaining ring.

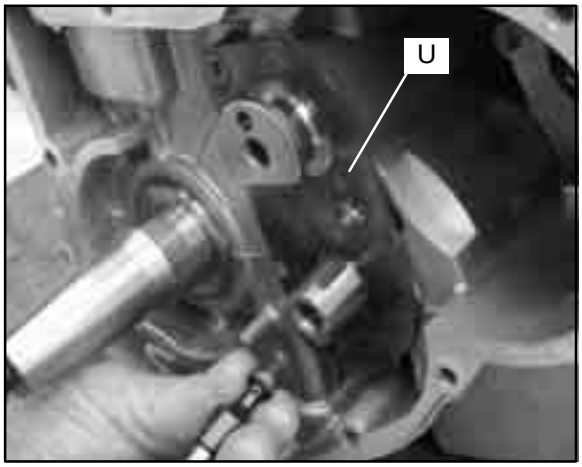


35. Press gear onto shaft while supporting the shaft.

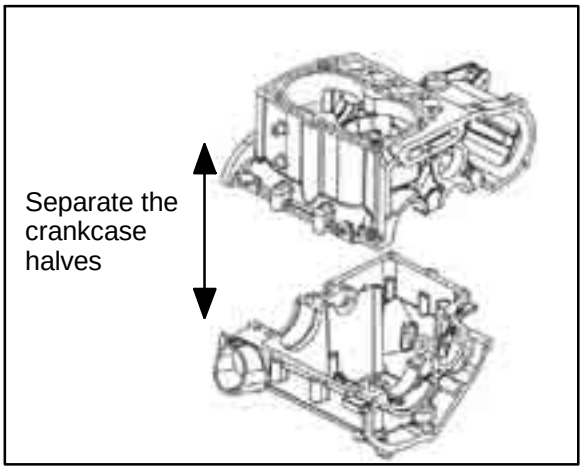


CRANKCASE DISASSEMBLY CONT'D

36. Remove thrust plate (U).

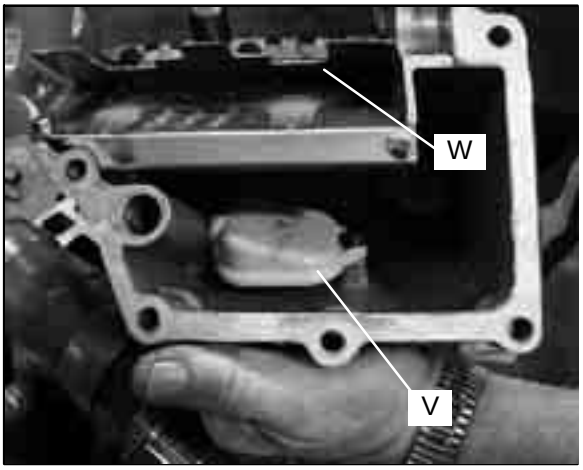


37. Remove PTO end engine mount. Remove crankcase bolts. Tap on the reinforced areas on the cases using soft hammer. Carefully separate the two crankcase halves.

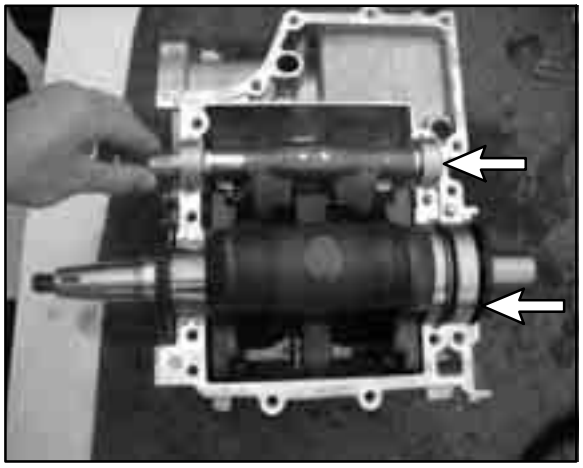


NOTE: Only remove the oil baffle if the baffle is damaged. When removing the oil baffle bolts, use a heat gun to heat the bolts and loosen the Loctite t . This will prevent any possible damage to the bolts or to the crankcase casting.

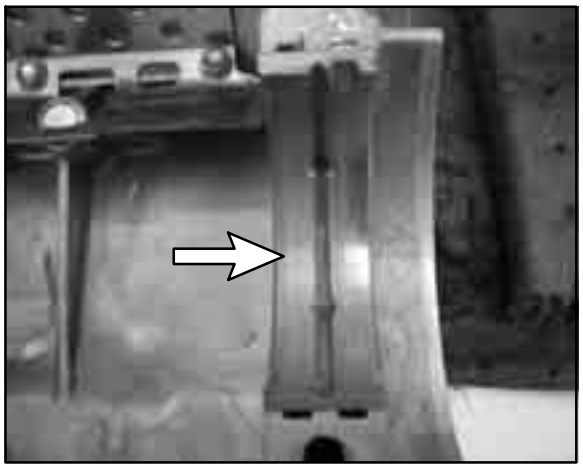
38. Remove and clean oil pick up (V) and oil baffle weldment (W).



39. Remove balance shaft and crankshaft.

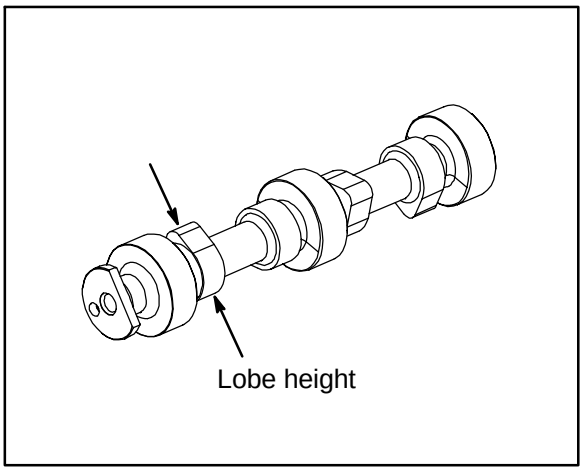


40. Remove and inspect crankshaft main journal bearings for abnormal wear. **It is recommended to replace the bearings anytime the engine is disassembled**.



CAMSHAFT INSPECTION

1. Thoroughly clean the cam shaft.
2. Visually inspect each cam lobe for wear, chafing or damage.

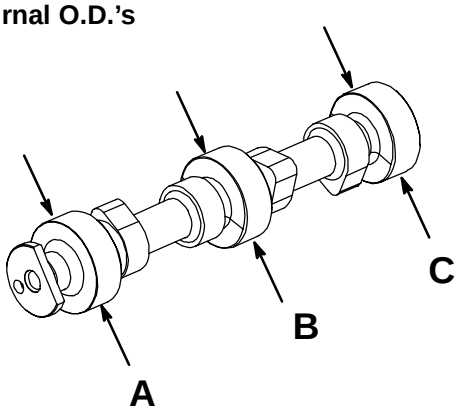


3. Measure height of each cam lobe using a micrometer. Compare to specifications.

Cam Lobe Height (Intake & Exhaust):
Std: 1.308" ± 0.0067"
(33.223 ± 0.1702 mm)

4. Measure camshaft journal outside diameters (O.D.)

Journal O.D.'s



Camshaft Journal O.D. :

A. (Mag): 1.654" ± .00039" (42 ± .010 mm)

B. (Ctr.): 1.634" ± .00039" (41.50 ± .010 mm)

C. (PTO): 1.614" ± .00039" (41 ± .010 mm)

5. Measure ID of camshaft journal bores.

Camshaft Journal Bore I.D.:

(Mag): 1.656" ± 0.00039" (42.07 ± 0.010 mm)

(Ctr.) 1.637" ± 0.00039" (41.58 ± 0.010 mm)

(PTO) 1.617" ± 0.00039" (41.07 ± 0.010 mm)

6. Calculate oil clearance by subtracting journal O.D.'s from journal bore I.D.'s. Compare to specifications.

Camshaft Oil Clearance:

Std: 0.00118" (.0299mm)
Limit: .0039" (.10 mm)

NOTE: Replace camshaft if damaged or if any part is worn past the service limit.

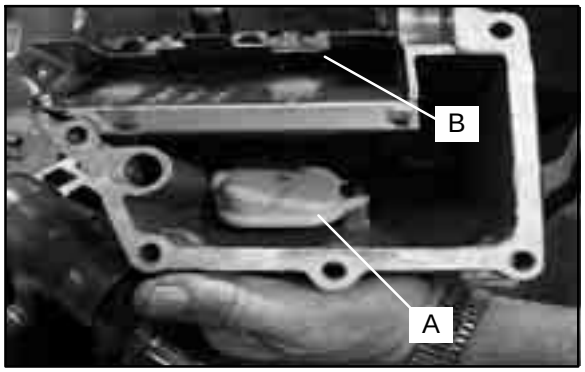
NOTE: Replace engine block if camshaft journal bores are damaged or worn excessively.

ENGINE CRANKCASE REASSEMBLY

WARNING: After any reassembly or rebuild, the engine must be primed using the Oil Priming Adapter (PU-45778) and a 3/4-full oil filter before initial start-up. Follow Steps 45-46 in this section to properly prime the engine and to help aid proper engine break in.

NOTE: Before assembly, clean the bolts and bolt holes with Primer N (**PN 2870585**) to remove any debris. This will ensure proper sealing when installing bolts.

1. Install oil pick up (A), if removed. Torque bolt to 60 ± 6 in. lbs. (6.8 ± 0.68 Nm).



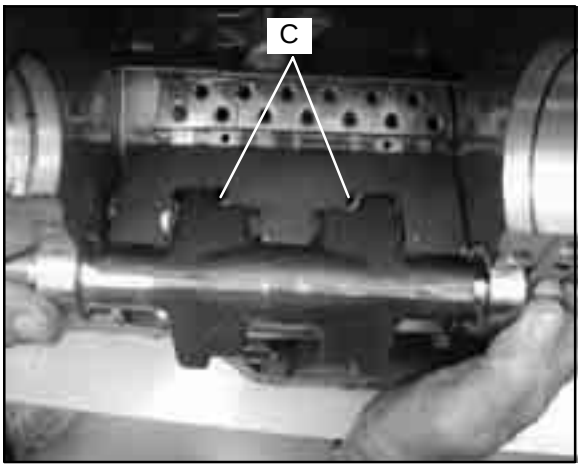
2. Install oil baffle weldment (B). Torque bolts to 60 ± 6 in. lbs. (6.8 ± 0.68 Nm).

Oil Baffle Weldment & Oil Pick Up-Bolt Torque:

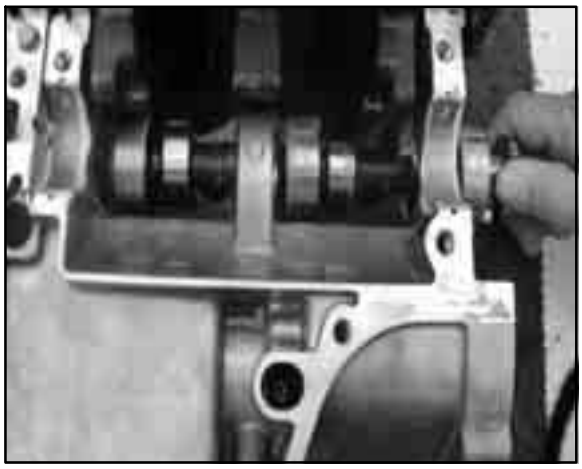
60 ± 6 in. lbs. (6.8-0.68 Nm)

3. Install the balance shaft. Inspect balance shaft clearance (C) in both gearcase halves. Rotate balance shaft to ensure that there is clearance between it and oil baffle weldment.

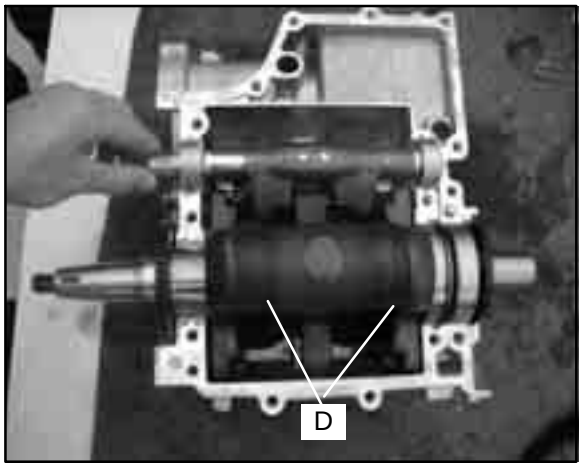
NOTE: Always install new balance shaft bearings.



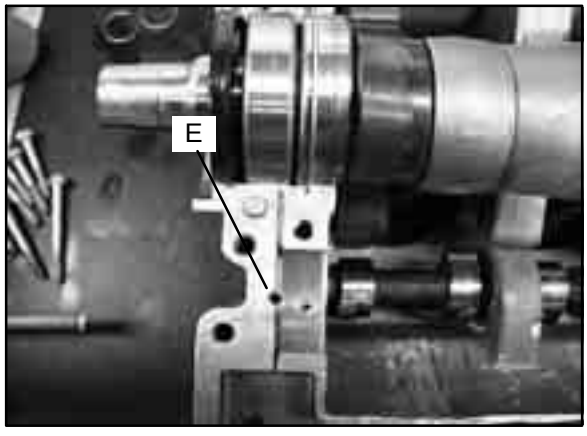
4. Apply Moly Lube Grease to cam journals and balance shaft bearing surfaces of the MAG case halve. Install cam and balance shafts.



5. Install crankshaft assembly and apply engine oil to crank pins and rods (D). Apply Moly Lube Grease to the main journals and bearings.



6. Apply Crankcase Sealant (**PN 2871557**) to the top gearcase halve.



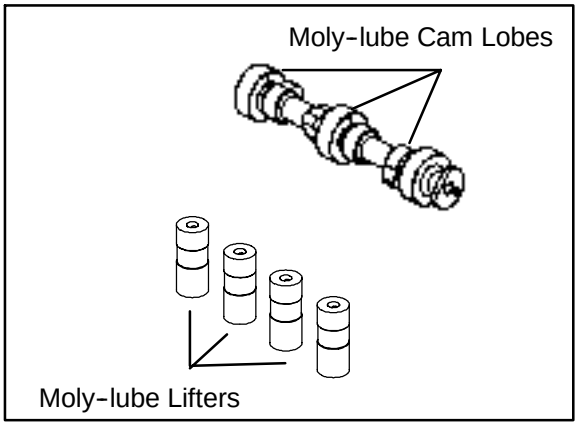
NOTE: Do not apply sealant to cam relief hole (E).

7. Assemble the crankcase halves. Apply LocTite t 242 (**PN 2871949**)to the threads and pipe sealant to the bolt flanges. Torque bolts to 22 ± 2 ft. lbs. (30 ± 3 Nm) following torque pattern on **Page 3.10**.

Crankcase Bolt Torque:

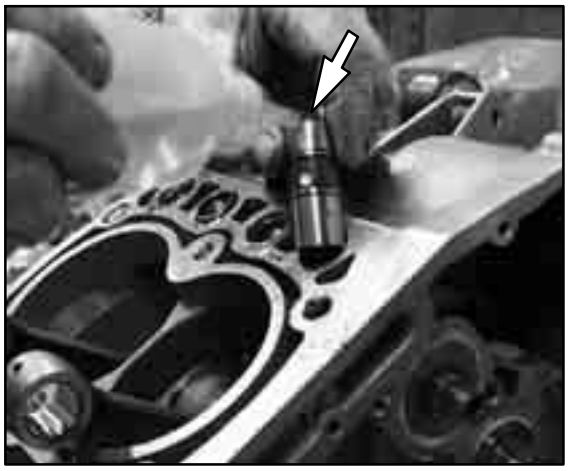
22 ± 2 ft. lbs. (30 ± 3 Nm)
***Torque in Proper Sequence (Pg. 3.10)**

8. Lubricate cam lobes and valve lifters with Moly Lube Grease.

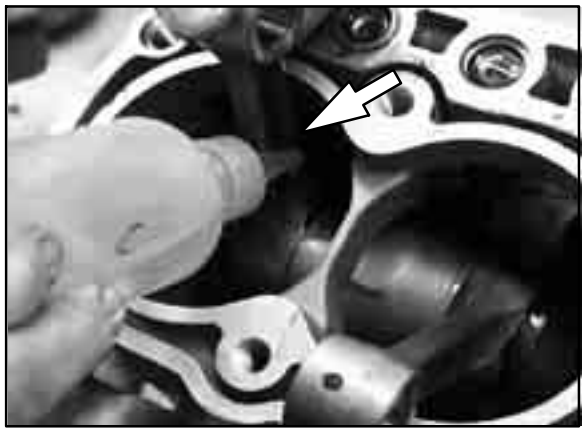


9. Lubricate lifters with engine oil and install in the original order as removed in disassembly. Apply Lubriplate or Moly Lube to the ends of the lifters.

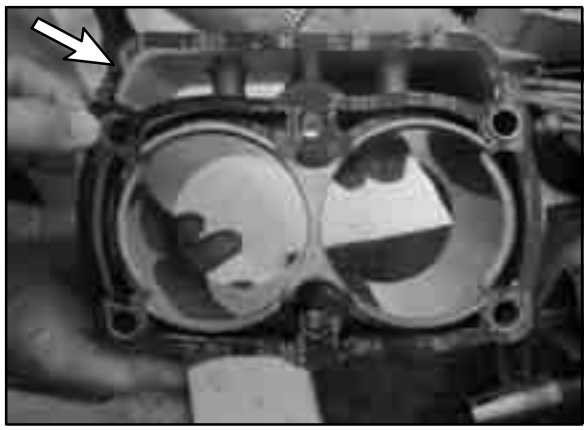
NOTE: Always replace the camshaft and lifters as a set.



10. Lubricate connecting rods with 0W–40 engine oil.

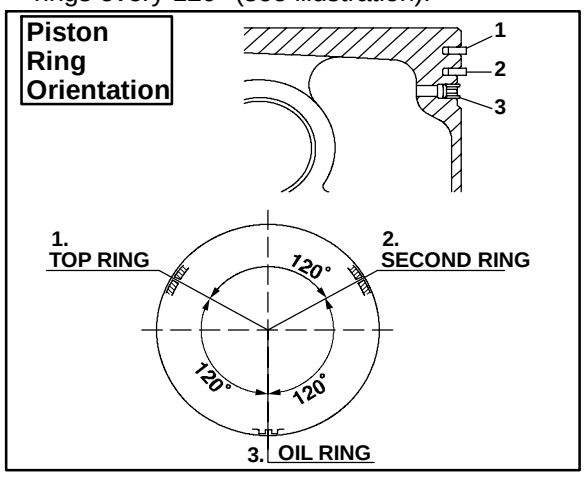


11. Install new cylinder gasket on crankcase. Align gasket on the dowel pins for proper gasket alignment.

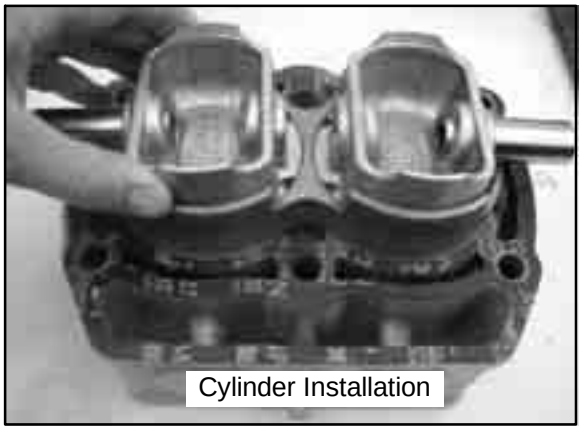


NOTE: Gasket must be installed dry. Do not use sealers or lubricants to hold in place during installation.

12. Orientate the piston rings on the piston before installation into the cylinders. Set the gaps of the rings every 120° (see illustration).



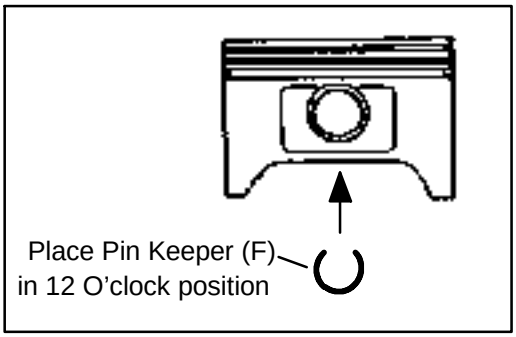
13. Install piston assemblies into cylinder aligning the piston pin holes, to ensure proper alignment of the pistons to the connecting rods upon assembly. Partially install the piston pins into the pistons.



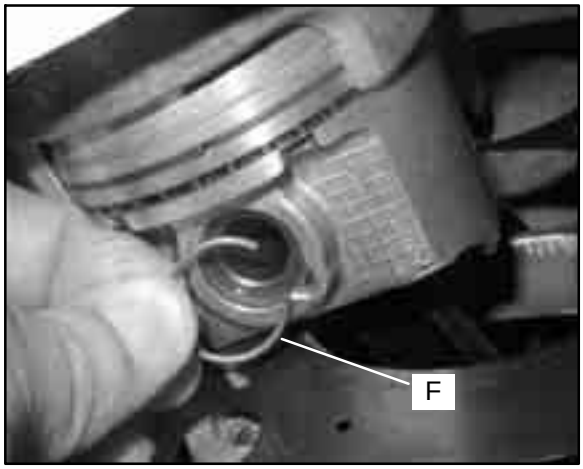
NOTE: To help align the pistons, slide a rod that is close to the same diameter as the wrist pin holes to properly align them in the cylinder.

14. Position cylinder and piston assemblies onto the connecting rods and push the piston pins through the piston and connecting rods.

15. Install the piston pin keepers (F). The pin keeper ends should be installed at the 12 O'clock position.

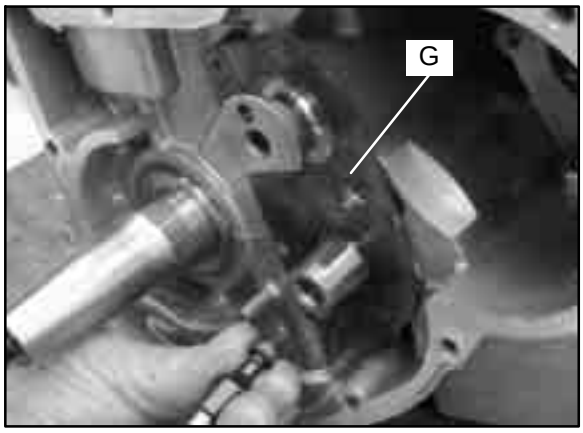


NOTE: While installing piston pin clips, cover all engine passages. The clip could fall into the engine during installation.



16. Install camshaft thrust plate (G) with new bolts. Torque bolts to 98 ± 10 in.lbs. (11 ± 1.13 Nm).

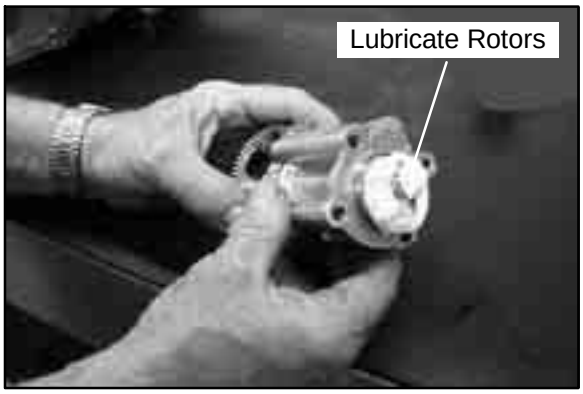
NOTE: New bolts have patch lock on the threads and do not require Loctite t .



17. Assemble rotors as marked when disassembled. Use a cleaner to remove the marks previously made on the rotors.

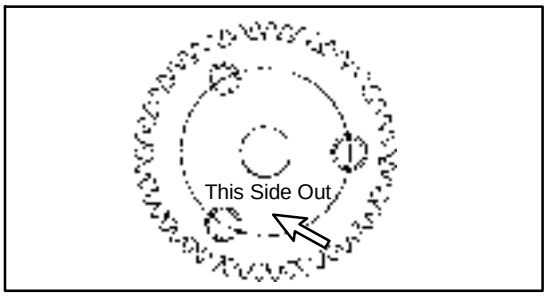
18. Apply moly lube, lubriplate, or oil to the rotors on the oil pump shaft.

NOTE: The application of oil or lubriplate aids in priming the oil pump during initial engine start up.



19. Align the bolt holes and install oil pump assembly into crankcase. Rotate the rotors in the housing during installation, as this checks for binding if new rotors are used.

NOTE: For assembly of the gears, the cam gear and the crankshaft gear are stamped with “This Side Out.” This indicates the side of the gear that faces outward or away from the case.

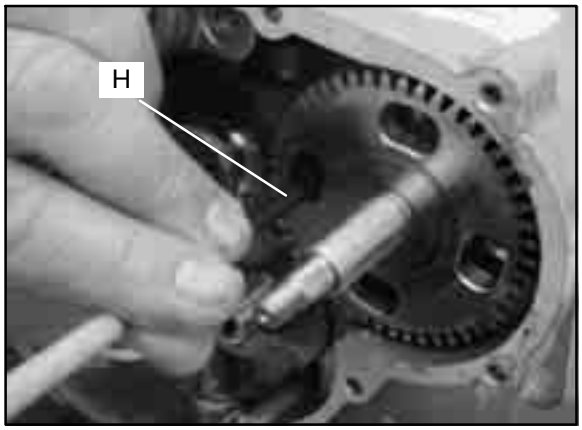


NOTE: Before assembly, clean the bolts and bolt holes with Primer N (**PN 2870585**) to remove any

debris. This will ensure proper sealing when installing bolts and new Loctite t .

20. Install oil pump housing bolts (H). The new bolts contain patch lock, so Loctite t is not needed on the new bolts. Torque bolts to 84 ± 8 in.lbs. (9.50 ± 0.90 Nm) and follow the torque sequence on Pg. 3.3.

NOTE: Occasionally spin the oil pump when installing bolts to check for binding of the rotors.

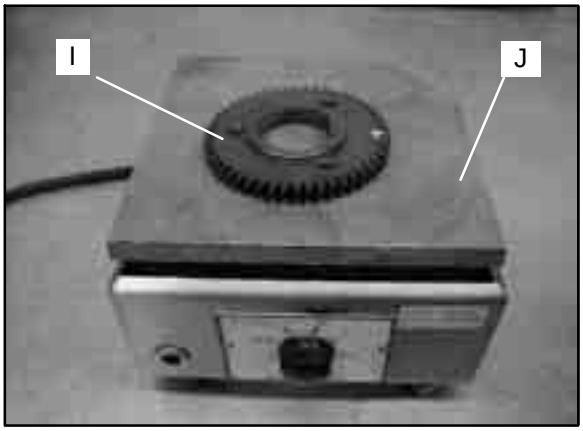


Oil Pump Bolt Torque:
84 ± 8 in.lbs. (9.50 ± 0.90 Nm)

***Torque in Proper Sequence (Pg. 3.3)**

21. Apply Loctite t 242 (**PN 2871949**) to the crankshaft.

22. Before installing the crankshaft gear (I), heat the crankshaft gear to 250° F (121°C) on a hot plate (J).

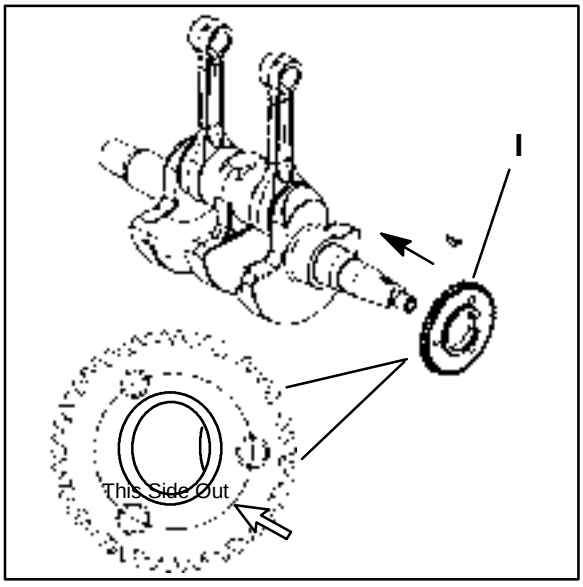


CAUTION:

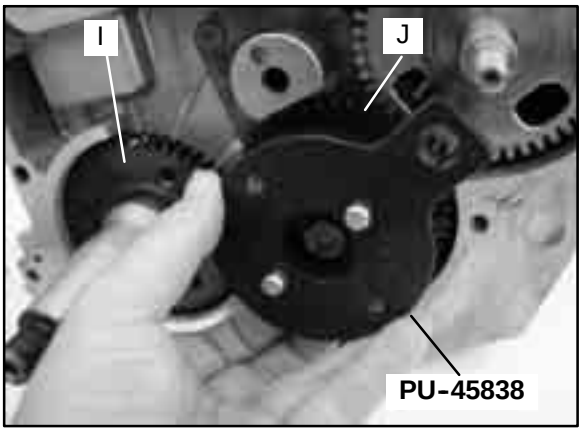
The crankshaft gear is extremely hot! Severe burns or injury can occur if the gear is not handled with extreme care and caution. Follow the procedure below to help ensure safety.

23. Use extreme caution when removing the crankshaft gear from the hot plate. Use a pair of pliers and leather gloves when handling the crankshaft gear.
24. Install the crankshaft gear (I) onto the crankshaft.

NOTE: For assembly of the gears, the cam gear and the crankshaft gear are stamped with “This Side Out.” This indicates the side of the gear that faces outward or away from the case.



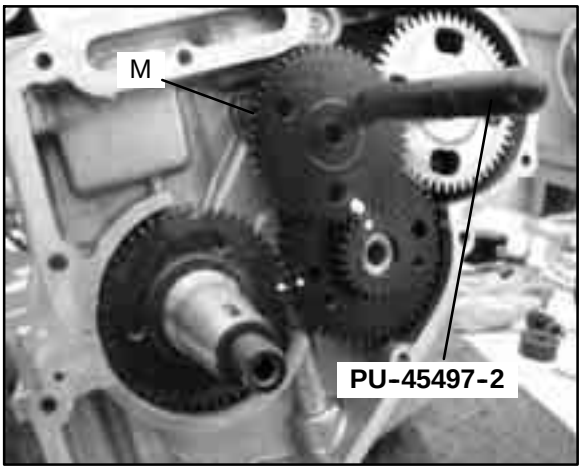
25. Install counter balance shaft gear (J) with new key, aligning timing marks with crankshaft gear (I). Install washer and bolt. Use the Gear Holder **(PU-45838**). Torque to 22 ± 2 ft. lbs.(30 ± 3 Nm).



Balance Shaft Gear Bolt Torque:

22 ± 2 ft.lbs. (30 ± 3 Nm)

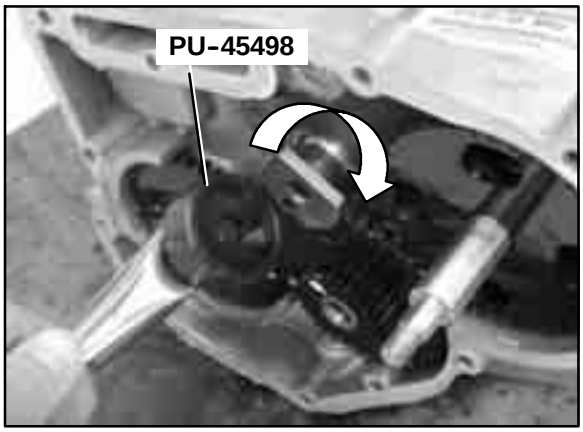
26. Use the Cam Gear Alignment Tool (**PU-45497-2**) to align the teeth of the cam gear (M). Install the cam gear (M) (with the Cam Gear Alignment Tool still in place) onto the camshaft. The timing marks on the camshaft gear should align with the keyway on the balance shaft gear.



NOTE: If the timing mark on the camshaft gear does not align properly, remove the camshaft gear and tool. Use the Cam Spanner Wrench (**PU-45498**) to rotate the cam to the proper position.

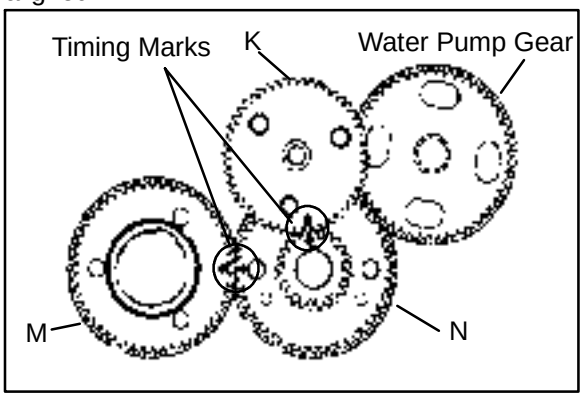
NOTE: Cam Spanner Wrench (**PU-45498**) is only needed to rotate the camshaft when the entire valve train is assembled.

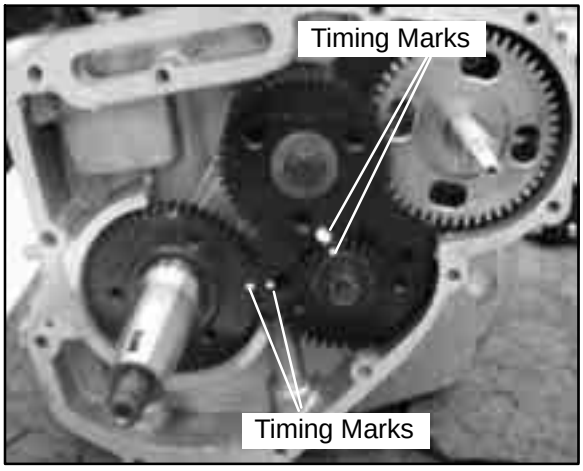
NOTE: Before installing the balance shaft gear bolt and washer, apply lithium grease between the washer and balance shaft gear.



27. Reinstall the camshaft gear; so the timing marks are properly aligned. Install the washer and bolt. Orientate the washer so the concave side is against the gear. Torque to 22 ± 2 ft. lbs.(30 ± 3 Nm).

NOTE: Be sure all of the timing marks are properly aligned.





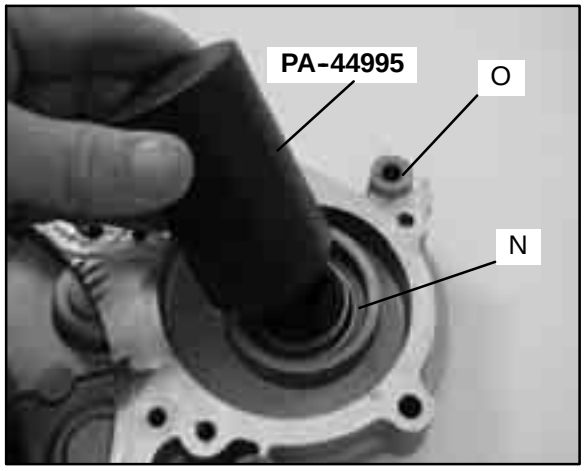
Counterbalance Gear and Camshaft Gear Bolt Torque:

22 ± 2 ft. lbs. (30 ± 3 Nm)

GEAR/STATOR HOUSING SEAL REPLACEMENT

IMPORTANT: Due to seal design and construction, these seals MUST be installed dry (no lubricant) during assembly. Use of lubricants (oil, soapy water, etc.) will not allow the seal to wear-in and seal properly. Do not touch seal surface or allow seal surface to come in contact with contaminates during installation. Thoroughly clean parts, tools and hands before installation.

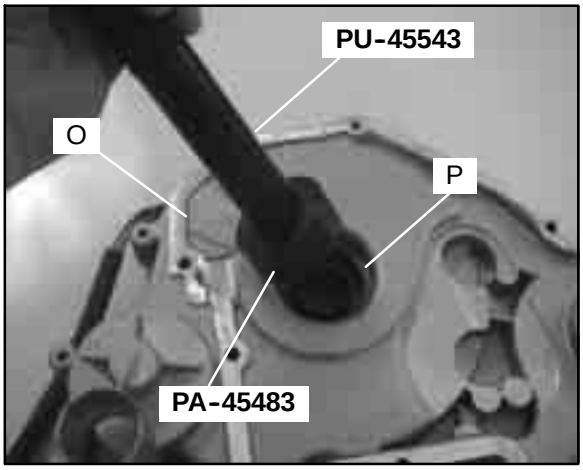
28. Before installing the gear/stator housing, replace the seals in the cover. Install a new water pump seal (N) into the gear/stator housing (O). Use the Water Pump Mechanical Seal Installer (**PA-44995**) to properly install the seal to the correct depth in the cover.



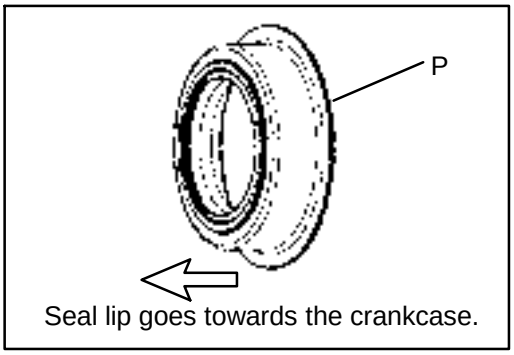
NOTE: To remove the water pump seal, the gear/stator housing must be removed. The water pump seal cannot be removed or installed with the gear/stator housing attached to the engine. Shaft damage will occur.

NOTE: Install the waterpump seal (N) with the seal lip facing out (towards the crankcase). Use of a hydraulic press is recommended for this procedure.

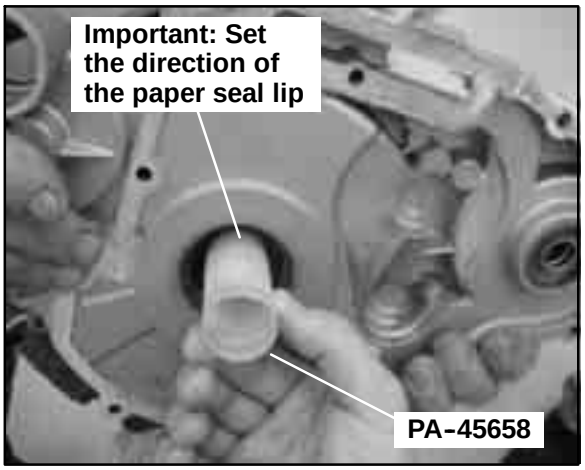
29. Install a new crankshaft seal (P) into the gear/stator housing cover (O). Use the Universal Driver Handle (**PU-45543**) and the Main Seal Installer (**PA-45483**) to seat the crankshaft seal into place.



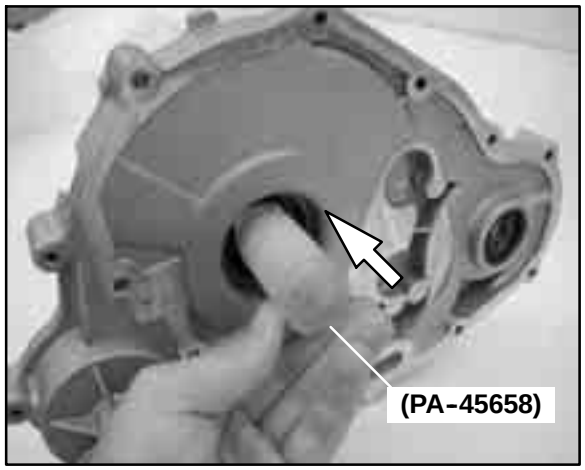
NOTE: Install the crankshaft seal (P) with the seal lip facing out (towards the crankcase).



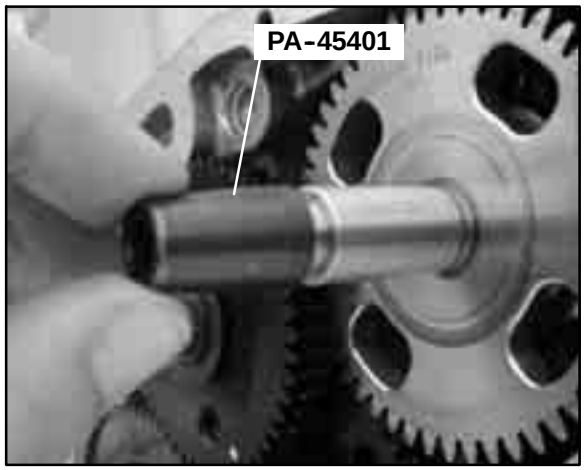
30. Once the crankshaft seal is installed into the gear/stator housing cover, set the direction of the paper lip by sliding the Main Crankshaft Seal Saver (**PA-45658**) into the crankshaft seal from the rubber lipped side to the paper lip side.(Back to Front) Remove the tool.



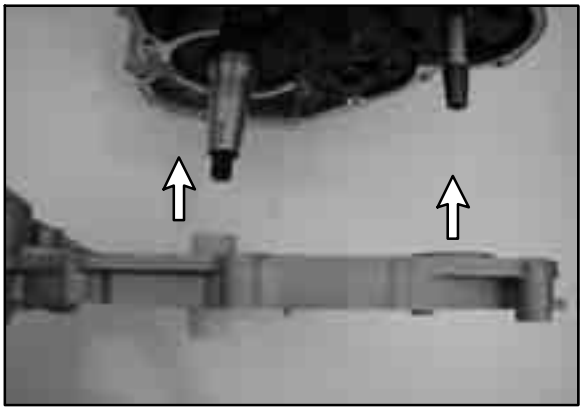
31. **Carefully** install the tapered end of the Crankshaft Seal Protection Tool (**PA-45658**) through the paper side of the crankshaft seal. (Back to Front) Leave the seal protector installed in the crankshaft seal. Check the crankshaft seal lips to verify they have not been rolled or damaged.



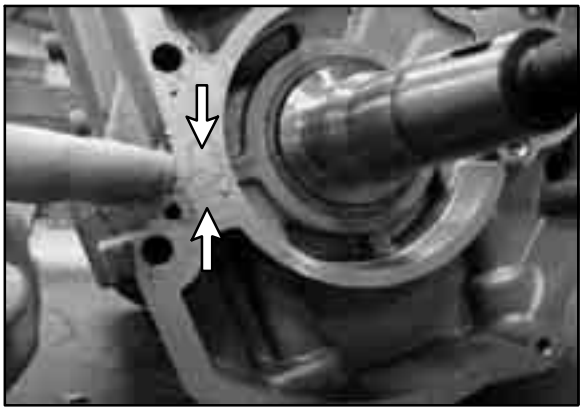
32. Before installing the gear/stator housing cover, install the Water Pump Seal Saver (**PA-45401**) onto the water pump shaft.

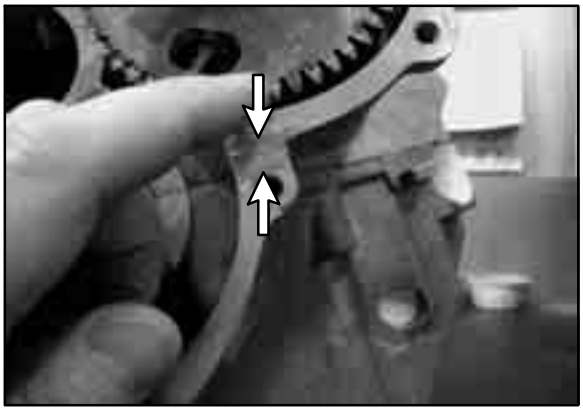


33. Install the new gasket to the gear/stator housing cover and crankcase. With the tools installed, carefully place the gear/stator housing cover over the protection tools. **NOTE:** New gasket is not shown in the picture.

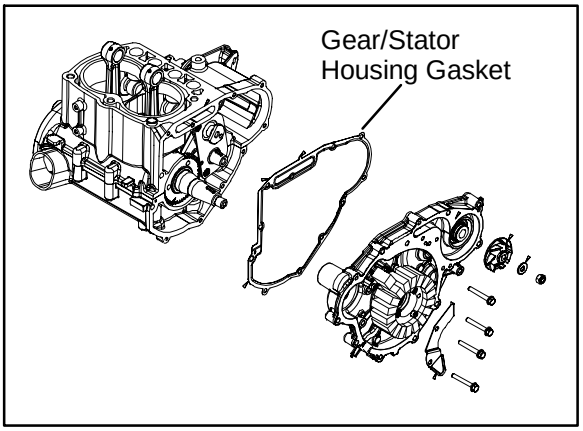


34. Apply Crankcase Sealant (**PN 2871557**) to the outside edges of the crankcase halves (See arrows), where the crankcases mate. (See photos below.) This helps to prevent coolant leakage.

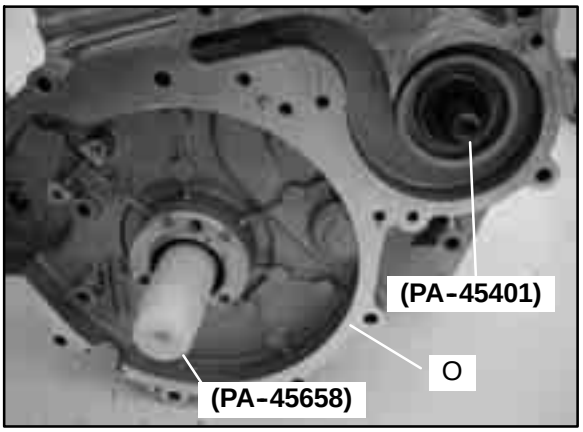




35. Install the gear/stator housing gasket onto he crankcase.



36. Secure the gear/stator housing cover (O) to the crankcase with the cover bolts. Torque bolts to 96 ± 12 in.lbs. (10.85 ± 0.35 Nm) in proper tightening sequence (see Pg. 3.3). Remove seal protectors from the shaft ends once secure.

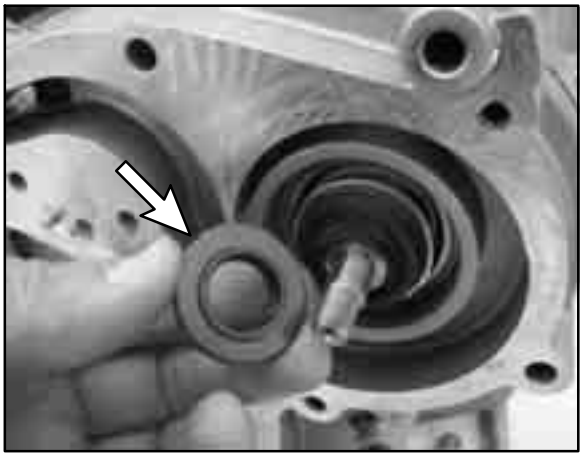


Gear/Stator Housing Bolt Torque:
96 ± 12 in. lbs. (10.85 ± 0.35 Nm)

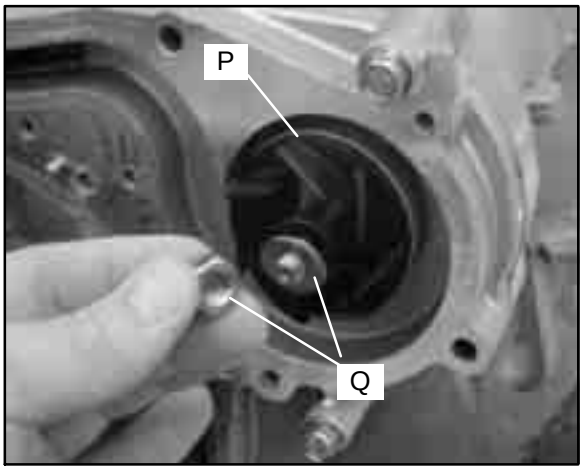
***Torque in Proper Sequence (Pg. 3.3)**

NOTE: Before assembly, clean the bolts and bolt holes with Primer N (**PN 2870585**) to remove any debris. This will ensure proper sealing when installing bolts.

37. Install shaft seal with ceramic surface facing inward.



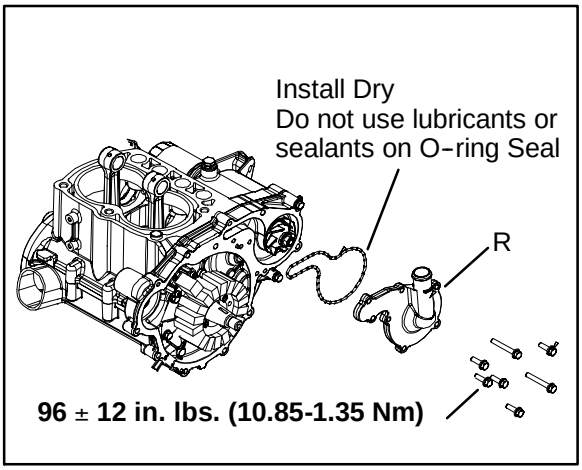
38. Install water pump impeller (P). **Secure the impeller with the washer and a <u>new nylok nut (Q)</u>.** Torque the nut to 108 ± 12 in. lbs. (6.8 ± 0.68 Nm).



Water Pump Impeller Nut Torque:

108 ± 12 in. lbs. (6.8 ± 0.68 Nm)

39. Install water pump cover (R) with new O-ring seal. Torque bolts to 96 ± 12 in. lbs. (10.85 ± 0.35 Nm) in proper sequence (See Pg. 3.4).



Water Pump Housing Bolt Torque:
96 ± 12 in. lbs. (10.85-1.35 Nm)

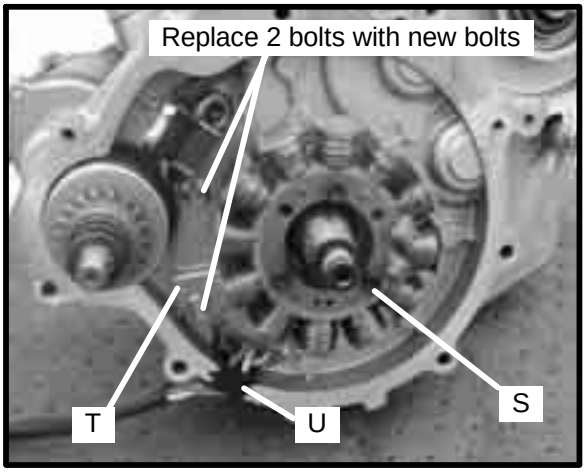
***Torque Bolts in Proper Sequence (Pg. 3.4)**

40. Sparingly apply Starter Drive Grease (**PN 2871423**) to the starter drive. Install the starter bendix.

NOTE: There are thrust washers on both sides of starter drive.

41. Install stator assembly (S) and bolts. Torque bolts to 96 ± 12 in.lbs. (10.85 ± 0.35 Nm).
42. Install the the wire hold down bracket (T). Install two new wire hold down bolts. New bolts contain patch−lock. Torque bolts to 96 ± 12 in.lbs. (10.85 ± 0.35 Nm) and follow the proper bolt torque sequence on Pg. 3.3). Coat the stator wire grommet (U) with Nyogel t Grease (**PN 2871329**).

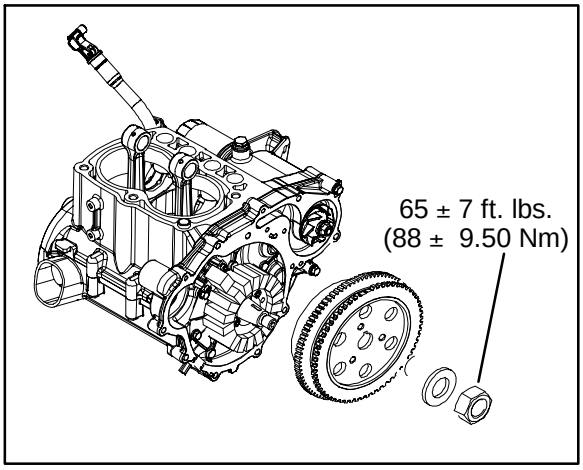
NOTE: Be sure the stator wires are routed properly under the wire hold down bracket.



Stator Assembly Bolt Torque:

96 ± 12 in.lbs. (10.85 ± 0.35 Nm)

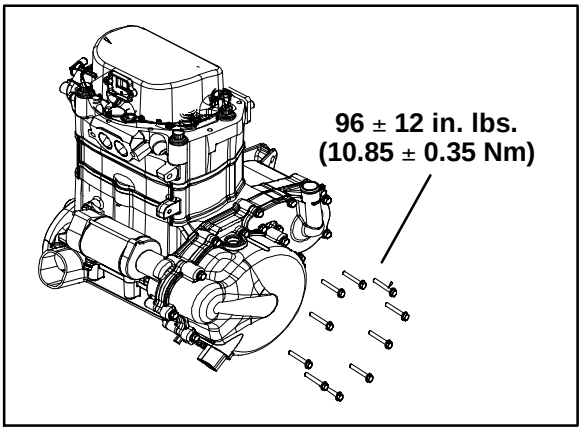
43. Install the flywheel, washer, nut, and key. Torque flywheel nut to 65 ± 7 ft. lbs. (88 ± 9.50 Nm).



Flywheel Nut Torque:

65 ± 7 ft. lbs. (88 ± 9.50 Nm)

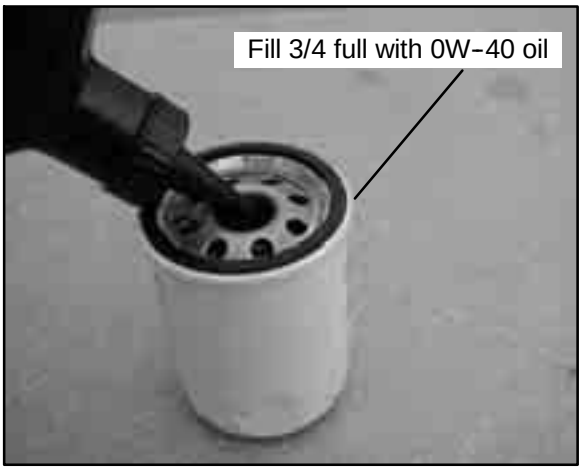
44. Install stator housing with new O-rings. Torque the bolts to 96 ± 12 in.lbs. (10.85 ± 0.35 Nm) and follow proper bolt torque sequence Pg. 3.4.



Stator Housing Bolt Torque:
96 ± 12 in. lbs. (10.85 ± 0.35 Nm)

***Torque in Proper Sequence (Pg. 3.4)**

45. After the engine is completely assembled and ready for installation, the engine must be properly primed with Polaris 0W-40 Synthetic Oil (**PN 2871281**). Fill the oil filter three-quarters full with Polaris 0W-40 Synthetic Oil (**PN 2871281**). Let the oil soak into the filter for 8-10 minutes. Install the filter onto the engine.



46. Remove primer plug from the engine. Install the Oil System Priming Adapter (**PU-45778**) into the oil plug hole. Push 3-5 oz. (approx.) of Polaris 0W-40 into the adapter until resistance is felt. Remove the adapter. Apply pipe dope or Teflon tape to the plug threads. Install the plug and torque to 216 ± 24 in.lbs. (24.4 ± 2.71 Nm).

Oil System Priming Adapter:

(PU-45778)

WARNING: After any reassembly or rebuild, the engine must be primed using the Oil Priming Adapter (PU-45778) and a 3/4-full oil filter before initial start-up. Follow the steps in this section to properly prime the engine and aid proper engine break in. Failure to perform this procedure may cause internal engine damage on initial start-up.

TROUBLESHOOTING

Spark Plug Fouling

- Spark plug cap loose or faulty
- Incorrect spark plug heat range or gap
- PVT system calibrated incorrectly/ components worn or mis-adjusted
- Fuel quality poor (old) or octane too high
- Low compression
- Restricted exhaust
- Weak ignition (loose coil ground, faulty coil, stator)
- Restricted air filter (main or pre-cleaner) or breather system
- Improperly assembled air intake system
- Restricted engine breather system
- Oil contaminated with fuel

Engine Turns Over But Fails to Start

- No fuel
- Dirt in fuel line or filter
- Fuel pump inoperative/restricted
- Tank vent plugged or pinched
- Engine flooded
- Low compression (high cylinder leakage)
- No spark (Spark plug fouled) ignition component failure

Engine Does Not Turn Over

- Dead battery
- Starter motor does not turn
- Engine seized, rusted, or mechanical failure

Engine Runs But Will Not Idle

- Low compression
- Crankcase breather restricted

Engine Idles But Will Not Rev Up

- Spark plug fouled/weak spark
- Broken throttle cable
- Obstruction in air intake
- Air box removed (reinstall all intake components)
- Reverse speed limiter limiting speed
- Incorrect ignition timing
- Restricted exhaust system
- Cam worn excessively

Engine Has Low Power

- Spark plug fouled
- Cylinder, piston, ring, or valve wear or damage (check compression)
- PVT not operating properly
- Restricted exhaust muffler
- Cam worn excessively

TROUBLESHOOTING, CONT

Piston Failure - Scoring

- Lack of lubrication
- Dirt entering engine through cracks in air filter or ducts
- Engine oil dirty or contaminated

Excessive Smoke and Carbon Buildup

- Excessive piston-to-cylinder clearance
- Wet sumping
- Worn rings, piston, or cylinder
- Worn valve guides or seals
- Restricted breather
- Air filter dirty or contaminated

Low Compression

- Cylinder head gasket leak
- No valve clearance (cam wear)
- Cylinder or piston worn
- Piston rings worn, leaking, broken, or sticking
- Bent valve or stuck valve
- Valve spring broken or weak
- Valve not seating properly (bent or carbon accumulated on sealing surface)
- Rocker arm sticking

Backfiring

- Speed limiter system malfunction
- Fouled spark plug or incorrect plug or plug gap
- Exhaust system air leaks
- Ignition system faulty:
  - Spark plug cap cracked/broken
  - Ignition coil faulty
  - Ignition or kill switch circuit faulty
  - Ignition timing incorrect
  - Sheared flywheel key
- Poor connections in ignition system
- Valve sticking
- Air leaks in intake
- Lean condition

COOLING SYSTEM TROUBLESHOOTING

Overheating

- Low coolant level
- Air in cooling system
- Wrong type/mix of coolant
- Faulty pressure cap or system leaks
- Restricted system (mud or debris in radiator fins causing restriction to air flow, passages blocked in radiator, lines, pump, or water jacket, accident damage)
- Lean mixture (restricted injector, vents, fuel pump or fuel valve)
- Fuel pump output weak
- Electrical malfunction
- Water pump failure/ Loose impeller
- Thermistor failure
- Cooling fan inoperative or turning too slowly (perform current draw test)
- Ignition timing misadjusted
- Low oil level
- Spark plug incorrect heat range
- Faulty hot light circuit
- Thermostat stuck closed or not opening completely

Temperature Too Low

- Thermostat stuck open

Leak at Water Pump Weep Hole

- Faulty water pump mechanical seal (coolant leak)
- Faulty pump shaft oil seal (oil leak)

NOTES